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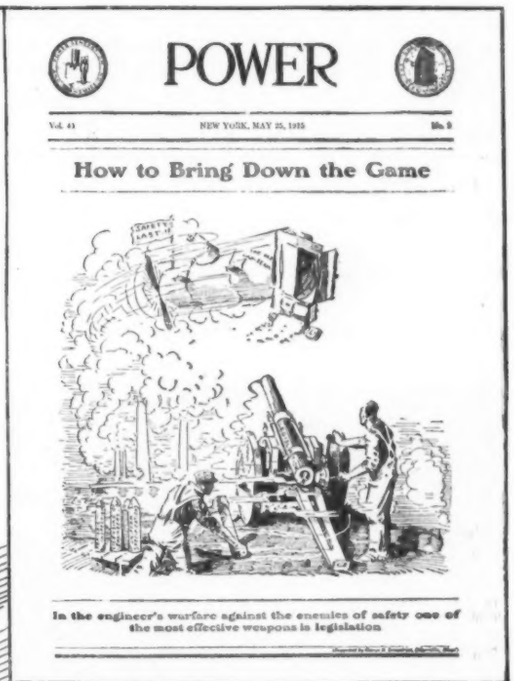
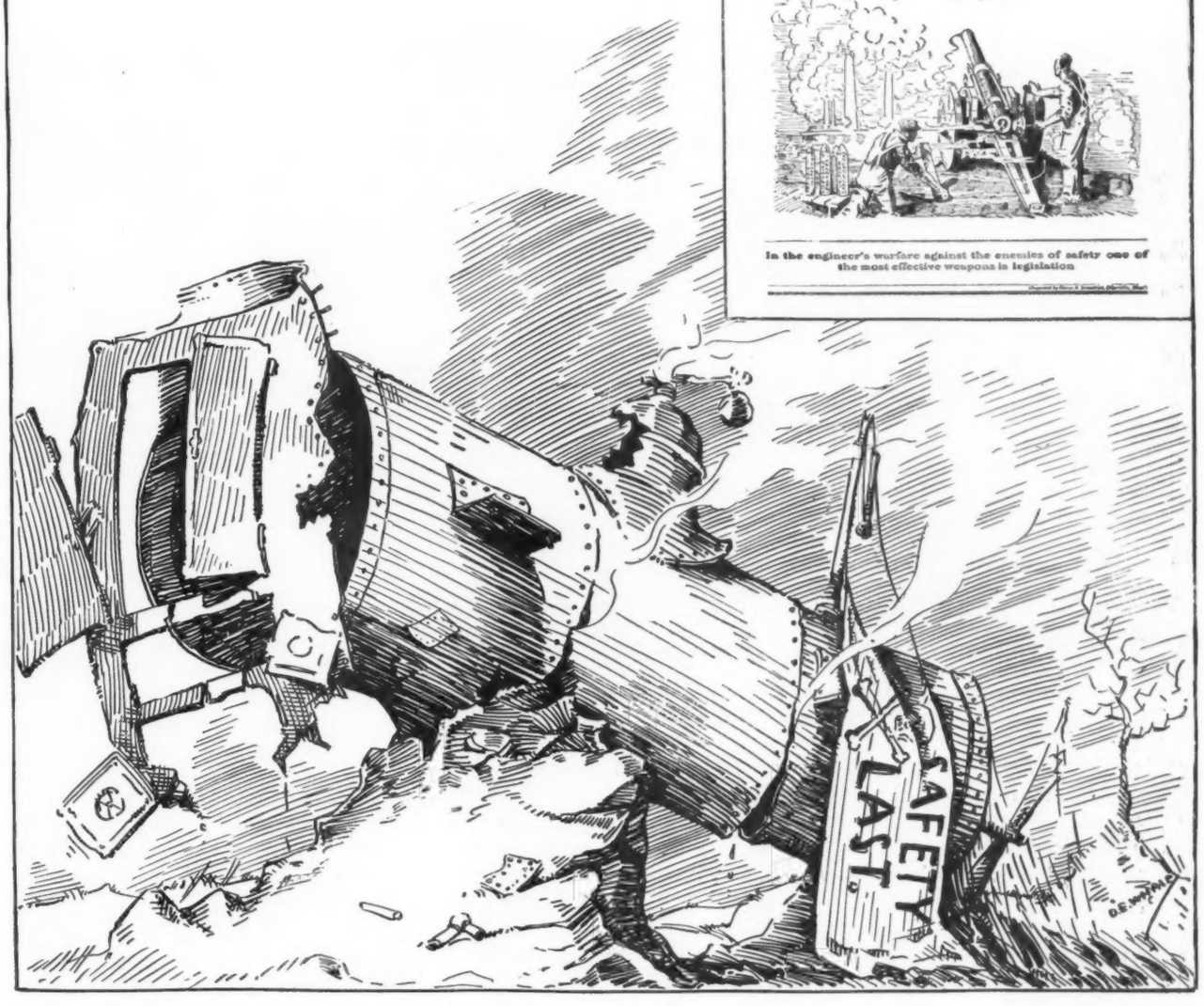
Bagged!

A Sequel to the Cartoon in POWER, May 25, 1915


POWER
How to Bring Down the Game
In the engineer's warfare against the enemies of safety one of the most effective weapons is legislation



What Happens Each Time Another State Adopts the A. S. M. E. Boiler Code

New Morrison Hotel Plant--I

By Thomas Wilson

SYNOPSIS—A modern plant equipped for the various services required by an uptodate hostelry. The generating plant has a capacity of 1000-kw direct current. The boilers have independent settings. Each is rated at 500 hp. with 5000 sq.ft. of heating surface. A vacuum system with steam nozzles removes the ashes. The three-wire system is used through the house. The piping system is of interest.

One of the landmarks of Chicago, the Morrison Hotel and the Boston Oyster House, is now passing through the transition period from a popular but old and timeworn hostelry into one of the most modern and best equipped hotels in the country. Over a year ago the first section of the new hotel was started, and it is now open to the public. Plans for a second section to replace the old hotel have been completed, and two more sections are in prospect.

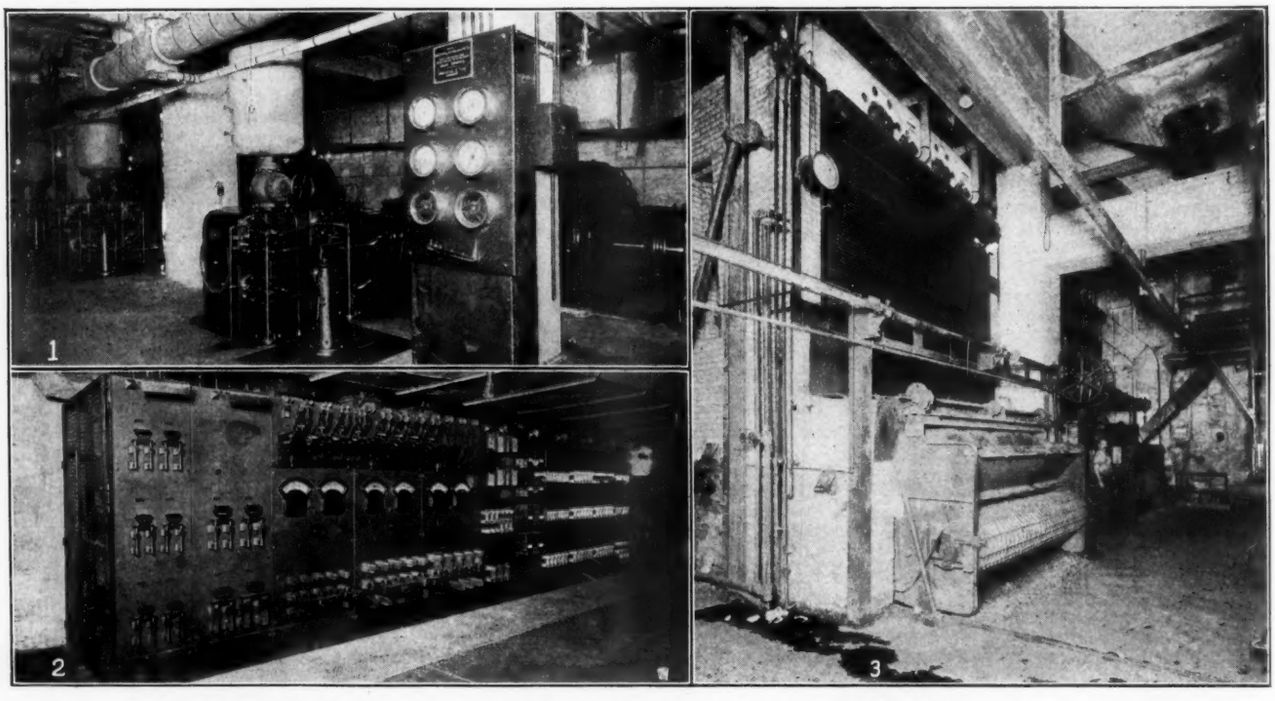


FIG. 1. THE THREE CORLISS ENGINE GENERATING UNITS. FIG. 2. SWITCHBOARD. FIG. 3. TWO OF THE 500-HP. BOILERS

The first installment contains 450 rooms. In plan it measures 70x185 ft. It is 22 stories high, rising 260 ft. above the sidewalk, and below there are four basements. In the one farthest down, 65 ft. below the street, is located the power plant that is now serving the first section, the old hotel and a number of other buildings in the block. It is also planned to care for the second section, which will have 600 rooms. Light, heat, power, refrigeration, ice-making, hot and cold water, vacuum cleaning and pneumatic-tube conveying are the principal services it is designed to maintain. The plant has a generating capacity of 1000 kw. in three units (Fig. 1), 1500 hp. in three water-tube boilers (Fig. 3) and 180 tons of refrigeration with provision for 120 tons more. The equipment is substantial and well laid out to produce efficient results. A number of interesting features have been incorporated which make the installation of more than ordinary interest.

Boiler-Room Equipment

The three boilers have independent settings. Each is rated at 500 hp., with 5000 sq.ft. of heating surface and 100 sq.ft. of grate in a chain-grate stoker. The latter is 10 ft. wide and 10 ft. long. Its area bears a ratio to the heating surface of 1 to 50. The boilers are of the three-pass type, vertically baffled. The bottom of the front header is 9 ft. above the floor. Over the fire an extended arch and a corbelled bridge-wall form a contracted area through which the gases enter the first pass. At the rear the gases pass up around the drums and through a sweeping turn into the smoke flue, which is made of steel, asbestos-lined, and of uniform section, 6 ft. wide by 9 ft. high. Individual dampers at the boiler and one in the uptake control the draft. The steel stack which is 325 ft. high, is lined all the way up and is oval in section, measuring 6x9 ft. On the stack side of the damper the draft will average close to 1½ in. of water. The boilers are operated at 160 lb. pressure. They are equipped with soot blowers and through three pairs of connections an efficiency meter shows the draft over the fire and at the damper and the drop through the setting for each boiler. The stokers are operated by a small vertical engine or a motor. Both are belted to a shaft common to the three stokers, and by means of a friction clutch on each pulley either may be thrown into service. A sectional elevation of the boiler room is shown in Fig. 6.

Coal is delivered to the plant by wagon into three concrete bunkers, built under the alley and having a total capacity of 200 tons. Through an undercut gate at the bottom of each bunker, the coal is dropped into a traveling weigh hopper, which may be moved to a position in front of each boiler for delivery into the stokers. In the stoker hopper the coal is sprayed by means of a perforated 1¼-in. water pipe running across the top and controlled by a valve at the side of the stoker.

A vacuum system employing steam nozzles removes the ashes. From the pit under the stoker the ashes are raked into an 8-in. pipe, in which one $\frac{7}{16}$-in. and one ⅜-in. nozzle have sufficient power to convey the ashes 70 ft. in a horizontal direction and raise them 85 ft. to the tank. The latter delivers through an extended chute to the alley.

Two duplex 12x7x12-in. pumps feed the boilers. The returns from the heating system are pumped into a combination receiving and air separating tank that also has a float-control connection to the cold-water supply, and from here flow by gravity to two open feed-water heaters, each of 750-hp. capacity. These heaters are arranged in duplicate and may be operated singly or in parallel, depending upon the number of boilers in service. From the heaters the water flows by gravity to a suction header connected to the two feed pumps and also to two house pumps, which may be used to feed the boilers if at any time their services are required.

There is also a cold suction line for these four pumps from the surge tank, from which city water for house service and cooling water for the condenser of the refrigerating system is obtained. The boiler-feed pumps may then be used for house service if necessary. From the pumps the feed lines are arranged in duplicate, as shown in Fig. 7, and are cross-connected so that either may feed the boilers or they may be used independently and at the same time, one for boiler feeding and the other for boiler-washing service. Ordinarily, the line containing the venturi meter is used for boiler feeding. The low-pressure receiver may be eliminated and the vacuum pumps on the heating system discharged directly to the heater. There is also provision to discharge the receiver to the sewer should the returns for any reason become unfit for boiler use.

Electrical Plant Details

Three-wire 110-220-volt direct-current service is supplied to the building. The generators are of the interpole type directly connected to Corliss engines. Two of the units are rated at 400 kw. and the third at 200. The engine cylinders are 22x32 in. and 16x30 in. respectively, and the speed 150 r.p.m. From 5:30 a.m. to 1 a.m. the service of a 400-kw. unit is required. At the peak the load runs up to 550 kw., so that the smaller machine is needed to help out. The latter carries the load from 1 to 5:30 a.m.

The switchboard, Fig. 2, is of standard construction. The indicating instruments are of the flush-front type with brass trimmings. Watt-hour meters are installed to record the energy going to the different services. The indicating meters on the bus are mounted on swinging brackets at the end of the board, and at the top special reflectors illuminate the panels.

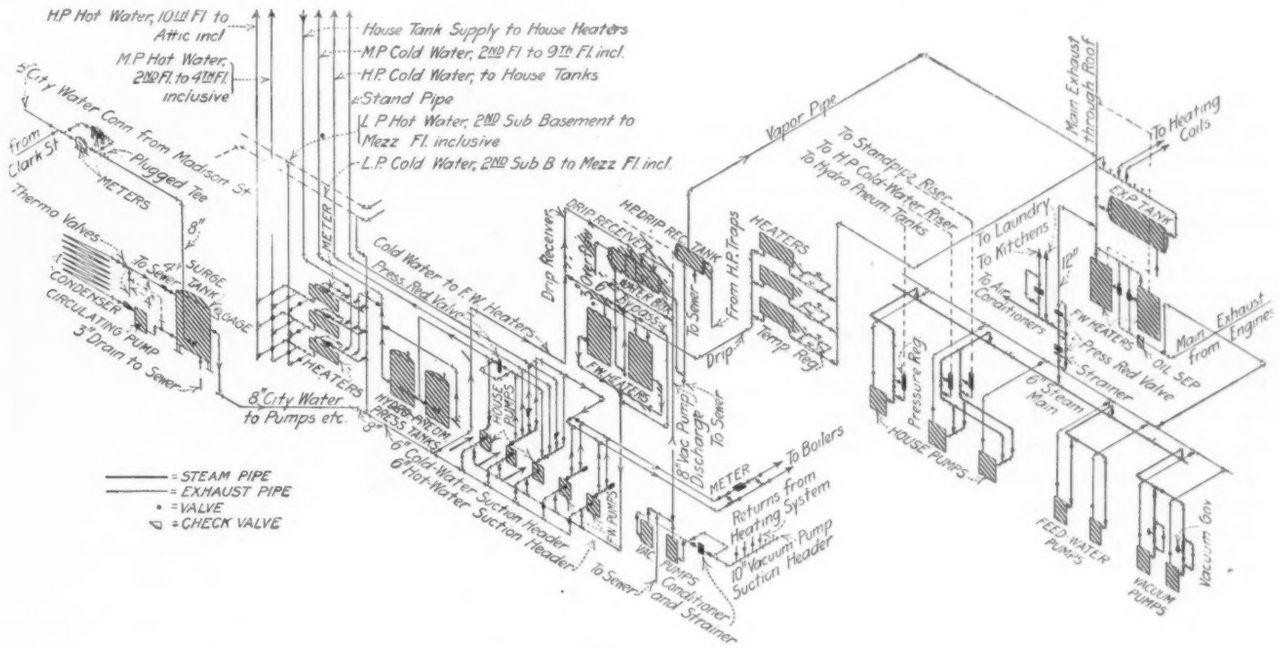


FIG. 4. DIAGRAM OF STEAM AND WATER PIPING, NEW MORRISON HOTEL PLANT

Steam and Water Piping

As shown in Fig. 5 there are two main steam headers, one 10 in. and the other 8 in. in diameter. Each boiler has a connection to each header, and a loop starting with the 10-in. and ending with the 8-in. header supplies the engines driving the electric generators and the CO_2 compressors. This loop extends the full length of the engine room and is so subdivided that any portion of it may be fed from either header, so that a breakdown of one unit does not affect the operation of the plant. Long-radius bends are used wherever possible, to take care of expansion. In the connections from the boilers to the headers pipe bends are used in preference to short 90-deg. ells. A 6-in. auxiliary high-pressure header connects the two main headers. The former supplies the pumps and, through reducing valves, the kitchen and laundry.

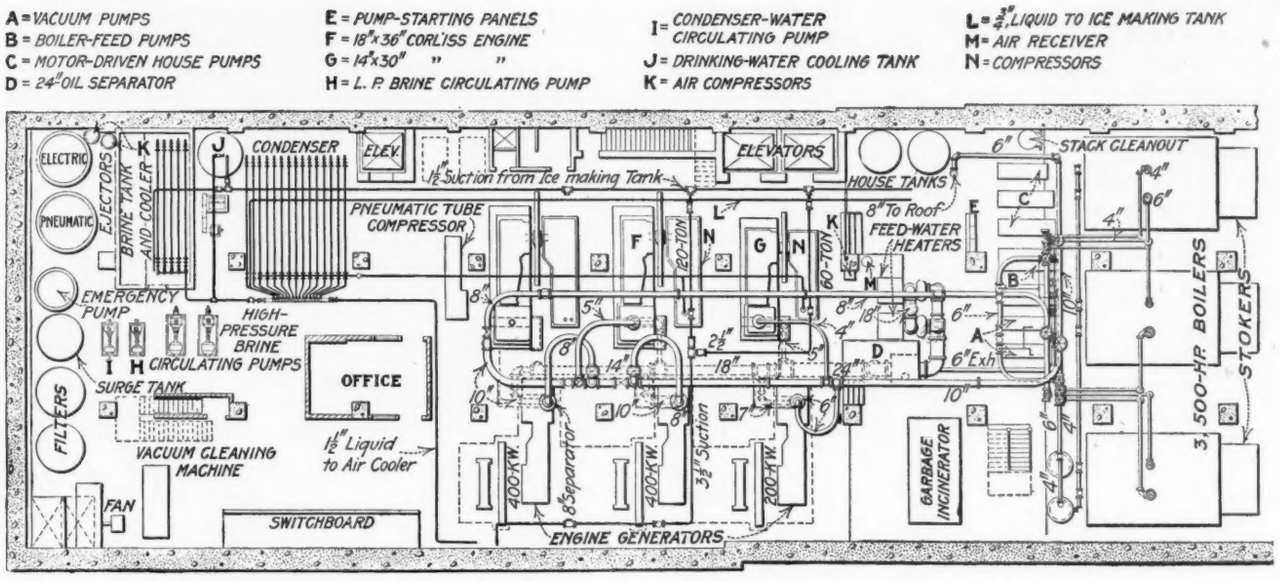


FIG. 5. GENERAL LAYOUT OF THE PLANT WITH KEY TO THE PRINCIPAL EQUIPMENT

Each boiler connection is provided with an automatic stop and check valve controlled by auxiliary pilot valves, one located in the boiler room and another near the engineer's office. In the leads supplying the engines, steel-plate receiver separators, having a volume 2½ times that of the cylinder, are in service. The main exhaust pipe, which is 24 in. in diameter, is carried in a tunnel beneath the engine-room floor. The exhaust steam is passed through a 24-in. horizontal oil separator and thence through two 18-in. oil separators to the feed-water heaters. Through a vertical riser it then passes through a muffler tank, which is provided with a perforated baffle and also acts as an oil separator, thence to a header from which it may pass to three 5000-gal. hot-water heaters of the closed type, to the vento coils and the heating system, or to atmosphere, as the various requirements dictate. It is evident that exceptional precautions have been taken to keep oil from reaching the heating system or the boilers, and during the short time the plant has been

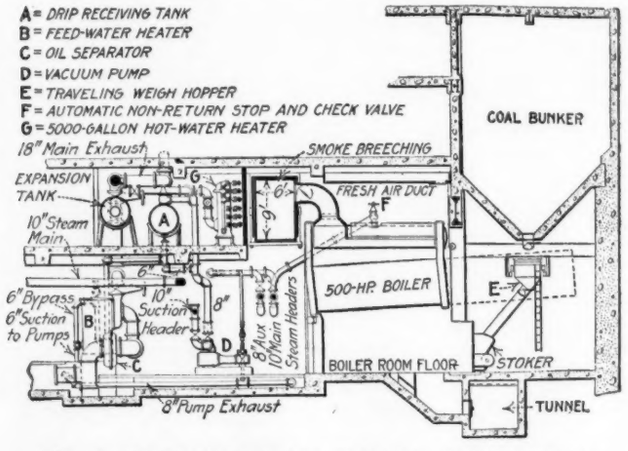


FIG. 6. SECTIONAL ELEVATION OF BOILER ROOM

in operation there has been no trace of oil in either. Fig. 4 is a diagram of the steam and water piping. Fig. 8, shows the exhaust-steam piping.

All of the piping has been painted a uniform color, and on the exterior of the pipe or the covering black arrows point the direction of flow and letters on the shaft of the arrow indicate the medium within. For example, c.w. stands for cold water, h.w. for hot water, i.w. for ice water, f.l. for fire line, etc.

Steam Heating System

In the first section of the hotel, just completed, 32,000 sq.ft. of direct radiation has been installed, this surface consisting mostly of low radiators located in front of the

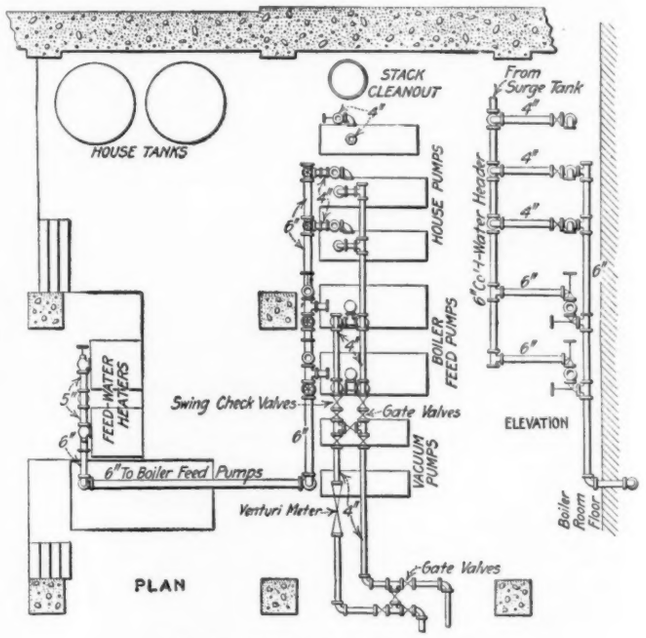


FIG. 7. FEED-WATER PIPING

windows and arranged for hand control. There is also an equivalent of 43,000 sq.ft. of direct radiation in vento coils for the ventilating system. In the other buildings served there is approximately 23,000 sq.ft. of surface, and in the second section of the new hotel which is to be installed shortly, it is estimated that there will be the equivalent of 58,000 sq.ft. of direct radiation.

All of the direct radiation in the new hotel is supplied by an overhead two-pipe vacuum system, starting from the 18-in. main exhaust riser near the attic ceiling. At

the lower sub-basement ceiling the supply mains terminate in a drip main, and parallel to this a second main collects the condensation from the return risers. These mains pitch back to the suction header of the vacuum pumps, and from here the water is returned to the boilers as previously described. There is also provision to bypass the returns to the sewer. All clean drips are collected in a high-pressure receiver vented to the main-exhaust riser, so that the vapor may be utilized for heating while the condensation is returned to the boiler-feed system.

Exhaust steam from the various engines and pumps has been sufficient to supply all demands in moderate

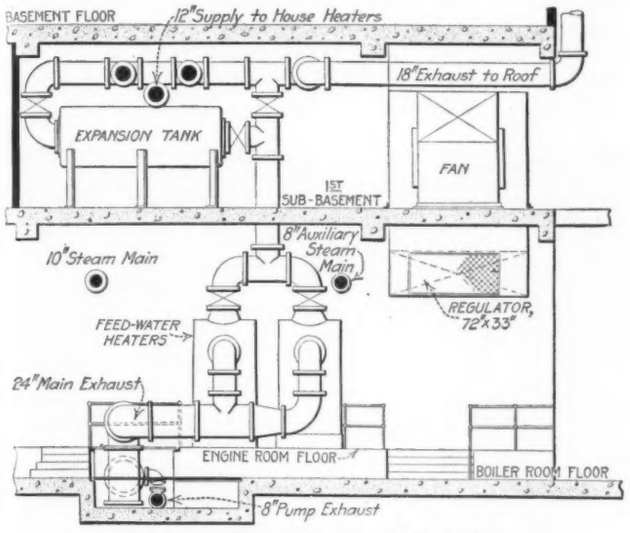


FIG. 8. EXHAUST STEAM PIPING

weather. When the temperature fell below 30 deg. F. some live steam was needed, and with the completion of the second addition the quantity will be considerably increased. The system imposes a back-pressure of ½ to 1½ lb.

Ventilation Arrangements

For ventilation a total of 307,800 cu.ft. of air is moved per minute. Of this 128,000 cu.ft. is fresh air and the balance exhaust. For general service four air changes per hour are allowed, and are effected by 11 fans of the multivane type, directly driven by 215 hp. in slow-speed motors provided with control for a range in speed from 10 per cent. above normal to 50 per cent. below. A feature of the system is the use of concrete tunnels in the floor construction for air ducts. Fresh air is taken into the building from the court at the level of the third floor, and adjustable dampers in each supply and exhaust opening permit regulation of the air flow. The fresh-air intakes have louvered dampers that may be controlled from the fan-room floor and in the concrete ducts there are dampers that are operated by socket wrenches.

Fans for the various sub-basements, including the engine and boiler room, for the grill room and the mezzanine floor and for the dining rooms and banquet halls are provided with air washers equipped with auxiliary spray nozzles and automatic flushing devices. The second and third of the aforementioned are also provided with humidity control and refrigerating coils, so that the temperature and humidity can be maintained at desired points. The refrigerating coils are inserted within the casings of the washers. Tempering coils have been provided between the fresh-air intake and the washer and reheating coils between the washer and the fans. These coils have temperature control and may also be regulated in sections by hand valves. The washer handling air for the sub-basements has a capacity of 40,000 cu.ft. per min., while the other two, serving the mezzanine floor, banquet halls, etc., have capacities of 24,000 and 30,000 cu.ft. per min., respectively.

[This article will be concluded in the next issue. The second installment will cover the refrigerating equipment, water service, elevators, and fire alarm and communicating systems. It will also include a table of the principal equipment giving the kind, size, use, operating conditions and maker.—Editor.]

Energy Transformation

By F. W. Swift

Energy, the ability to do work, cannot, according to the law of its conservation, be created or destroyed. Otherwise many more brains would be at work endeavoring to devise perpetual-motion machines. Energy cannot be manufactured, as the amount in the universe is absolutely unchangable and the one principle of energy that most concerns mankind is that of its transformation. This can be more clearly understood by following the various transformations effected to produce work or heat in an electrical device.

The radiant energy of the sun was imparted to vegetation centuries ago. This vegetation perished and by various processes was buried under the earth's crust and was transformed chemically to coal. Thus the sun's energy was stored up and is present in the coal.

In the boiler room another energy transformation takes place. Here the coal ignites and heat energy is derived, which is transferred to water, and steam is generated. Much of this heat energy goes up the stack and elsewhere and is not usefully expended.

Leaving the boiler, the heat energy passes to the engine or turbine in the form of steam. At the piston of the reciprocating engine or blade of the steam turbine a transformation takes place and mechanical energy is obtained. By the electric generator this is converted to electrical energy, which is delivered to the distributing lines and is brought to the electrical device. If this be one from which work is obtained, a motor for instance, the electrical energy is transformed back to mechanical energy, or in a heater the electrical energy is transformed back to heat energy.

Many transformations are thus necessary to produce the desired results in an electrical device.

Adding Heat to a Substance causes the molecules of which it is composed to vibrate more and more rapidly until the force of the vibration overcomes the force holding it together and the substance falls apart or is broken up, as ice into water and water into steam. The presence of ice in water acts like a brake (on this molecular vibration) and prevents the molecules of water speeding up, by the application of heat, enough to form steam or even increase the temperature of the water, but when the ice disappears or the brake is worn out, then speeding up begins to show in the form of temperature rise until the cooling effect of evaporation again applies the brake and prevents further rise in temperature (the pressure remaining constant) as long as there is water present, as in the previous case of the ice. With that brake off, or when the water is all evaporated, the temperature again begins to increase and appear as superheat.

Low-Pressure Turbine at the Carpenter Steel Mill

SYNOPSIS—The first instance in the United States, and the second in the world, where a mixed-pressure steam turbine fitted with reduction gears has been used to drive a rolling mill. It cost about $25,000 to install, and it is estimated that it will save $15,000 per year.

The accompanying illustrations are of the power plant that drives the roughing mill of the Carpenter Steel Co., Reading, Penn. This installation is of interest, because it is the first instance, in the United States, where a mixed-pressure steam turbine has been used for driving a rolling mill through the medium of speed-reducing gears.

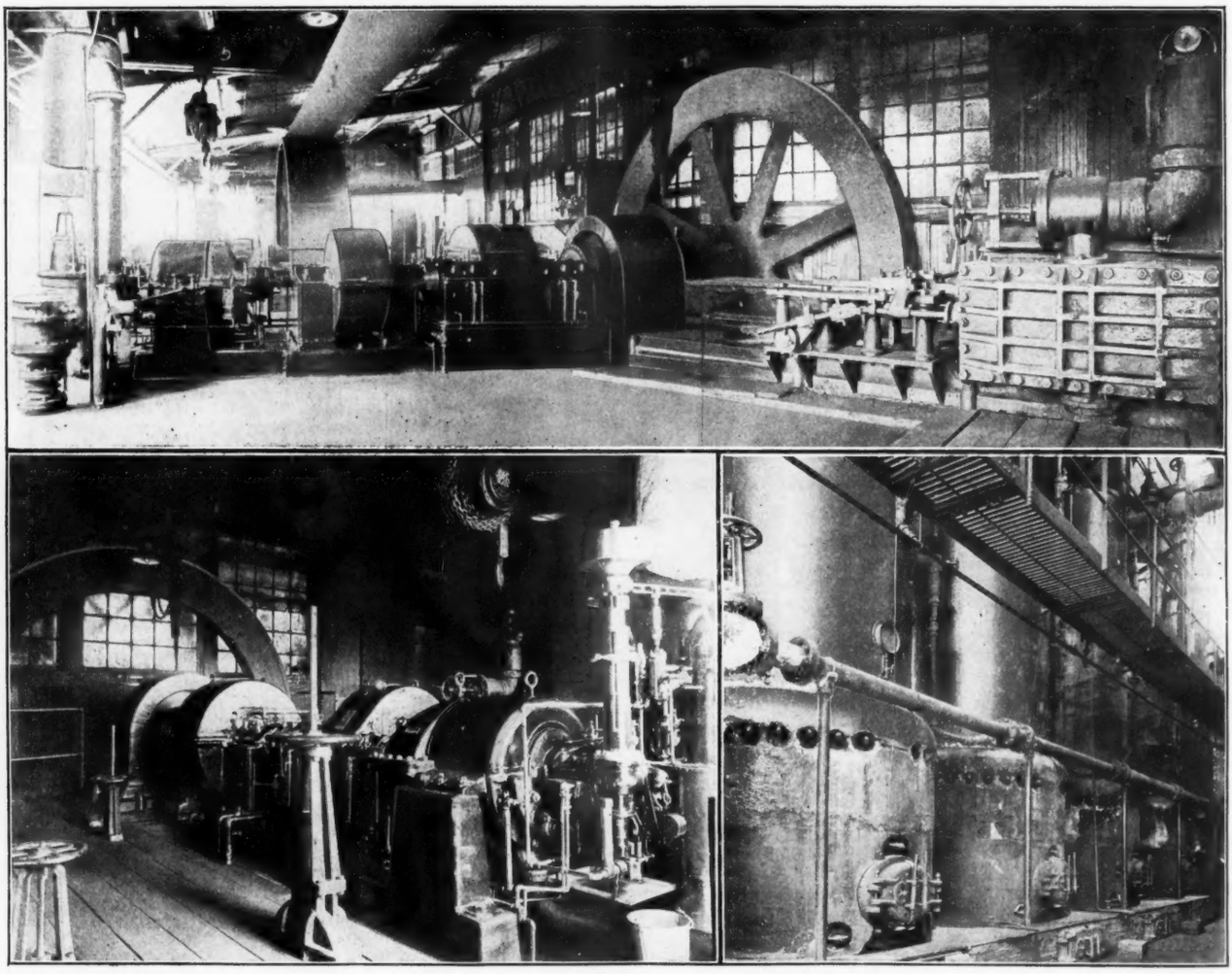


FIG. 1. MIXED-PRESSURE TURBINE AND SLIDE-VALVE ENGINE IT DISPLACED. BUT 600 OF THE 1000 HP. IN BOILERS ARE USED WITH THE PRESENT ARRANGEMENT

This unit was described on page 455 of the Mar. 30 issue, but no photographs were available at that time. The main features are as follows: The turbine is designed to develop 350 hp. at from 70 to 100 r.p.m. of the mill shaft, using steam from a 22&40x48-in. cross-compound Corliss engine at 3 lb. back pressure, and exhausting into a 27-in. vacuum. It can also develop 350 hp. when using steam at 120 lb. gage pressure and exhausting into a 27-in. vacuum, with not more than 17½ lb. of steam per brake horsepower per hour. When operating with both high- and low-pressure steam, and exhausting to a vacuum, the turbine is able to carry 600 b.hp. continuously. It is also able to carry 600 hp. on high-pressure steam when the compound engine is not running, using not more than 15.7 lb. of steam per b.hp.-hr. It can carry its normal load noncondensing, with steam at 120 lb. pressure.

When the turbine, Fig. 1, was installed it displaced a 36x36-in. simple slide-valve engine, the cylinder of which is shown in the upper illustration. The slow-speed shaft of the reduction gear of the De Laval turbine is in line with the shaft of the slide-valve engine, which, except that it has had its connecting-rod removed, has been left intact. This was to avoid interruption of the work while making the change and to provide against interruption of service in the future. The coupling between the reducing gears and the engine shaft, a distance disk which also serves as one of the flanges of the flexible coupling on the low-gear shaft, was bolted to the crank disk of the engine, a hole having been provided to accommodate the crankpin. A view of the boiler room

that supplies steam to the cross-compound engine is shown at the lower right-hand corner of the group. The boilers are rated at a total of 1000 hp., but because of the better economy secured through using the turbine the boiler output has been reduced to about 600 hp. The cost of installing the turbine was about $25,000, and it is estimated that it will save each year $15,000 in operating expense.

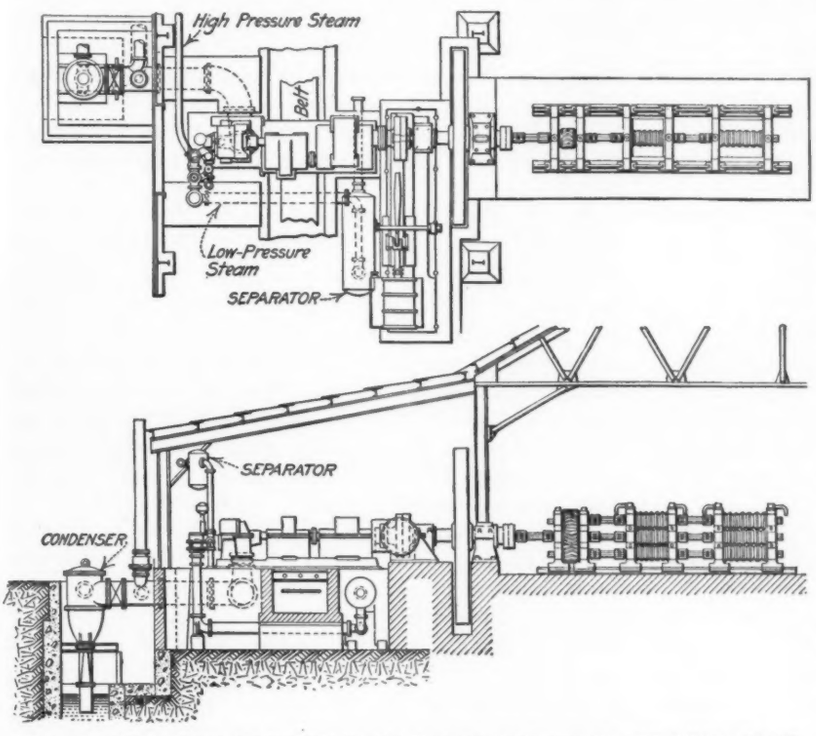


FIG. 2. PLAN AND ELEVATION OF MIXED-PRESSURE TURBINE DRIVING A ROLLING MILL THROUGH REDUCTION GEARS

Boiler Tests at Various Loads

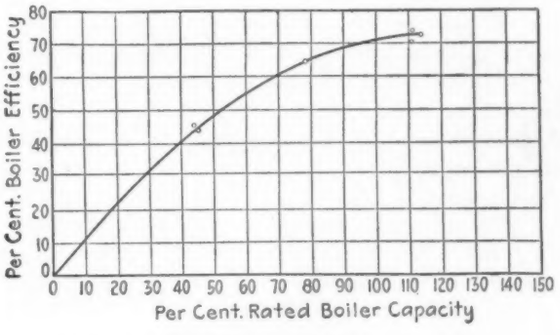
By Charles M. Rogers*

This article gives test data on a 750-hp. Stirling boiler. The results corroborate the wisdom of the present-day practice of carrying overloaded boilers to get better efficiency. They are also an argument in favor of installing the largest boilers the plant load will permit. The chart shows how the efficiency increased with the load. It might also be stated that during part of the day when these tests were conducted the boiler was running at about 200 per cent. of rating and the efficiency was no lower than at 115. Since the tests were conducted the coal has been changed to a lower grade, and the coal cost of evaporating 1000 lb. of water at present is 9.3c., the coal costing $1.65 at the plant.

The boiler was equipped with Murphy furnaces set in dutch oven, with 120 sq.ft. of grate surface, 480.8 sq.ft. of B. & W. superheater surface, and 7524 sq.ft. of heating surface. The coal used was Pratt run-of-mine with calorific value of 14,179 B.t.u. per lb. of dry coal and 15,835 per lb. of combustible. These results were obtained from coal samples taken each day and analyzed as one sample. The boiler was operated at approximately 100 deg. superheat.

Additional data in connection with the last three tests show that the CO_2 averaged between 12 and 13 per cent.; the heat lost to the ashes, 4.48 per cent.; heat lost to the stack, 16 per cent.; incomplete combustion losses, less than 1 per cent.; and radiation and unaccountable losses, between 6 and 7 per cent. The furnace and baffling arrangement on the boiler were designed to carry 1500 kw. economically in the engine room, and needless to say, this is being done.

The boiler was supposed to operate at 100 deg. superheat, and as it was impracticable to obtain the temperatures when the readings were taken, 100 deg. was assumed as correct.



EFFICIENCIES AT VARIOUS LOADS

*Meridian Light and Railway Co., Meridian, Miss.

RESULTS OF TESTS ON 750-HP. STIRLING BOILER

Duration, hr.	8	11	24	24	24	24
Steam pressure, by gage, lb.	150	150	150	150	150	150
Temperature of feed water entering boiler, deg. F.	202	195	190	200	200	200
Temperature of escaping gases leaving boiler, deg. F.	470	435	426	435	455	450
Draft over fire, in. of water	0.17	0.18	0.12	0.15	0.155	0.144
Weight of coal as fired, lb.	14,400	20,380	52,020	68,500	68,215	65,400
Percentage of moisture in coal	4.50	4.50	2.50	2.00	2.00	2.00
Total weight of dry coal consumed, lb.	13,752	19,800	50,720	67,100	66,850	64,100
Total ash and refuse, lb.	.....	.....	6,860	9,075	9,400	8,670
Percentage of ash and refuse in dry coal	.....	.....	.....	10.45	0.145	10.45
Total weight of water fed to the boiler, lb.	81,800	114,900	432,875	614,067	629,200	614,900
Total equivalent evaporation from and at 212 deg., lb.	91,550	128,700	487,100	691,500	708,380	692,000
Dry coal consumed per hr., lb.	1,719	1,800	2,114	2,795	2,785	2,671
Dry coal per sq.ft. of grate surface per hr., lb.	14.3	15.0	17.6	23.3	23.2	22.2
Water evaporated per hr., lb.	10,225	10,440	18,030	25,600	26,220	25,620
Equivalent evaporation per hour from and at 212 deg., lb.	11,444	11,700	20,300	28,800	29,520	28,850
Equivalent evaporation per hour from and at 212 deg. per sq.ft. of water-heating surface, lb.	1.52	1.55	2.70	3.83	3.92	3.84
Boiler horsepower developed	332	339	589	835	856	837
Rated boiler horsepower	752.4	752.4	752.4	752.4	752.4	752.4
Percentage of rated boiler capacity developed	44.1	45.2	78.2	111.0	113.8	111.2
Water fed per lb. of coal fired, lb.	5.68	5.54	8.32	8.97	9.22	9.41
Water evaporated per lb. of dry coal, lb.	5.95	5.81	8.53	9.16	9.41	9.59
Equivalent evaporation from and at 212 deg. per lb. of dry coal, lb.	6.66	6.49	9.61	10.31	10.59	10.8
Equivalent evaporation from and at 212 deg. per lb. of combustible, lb.	....	....	11.11	11.91	12.39	12.47
Efficiency of boiler, based upon dry coal, per cent.	45.6	44.6	65.7	70.1	72.0	73.5

Rewinding Direct-Current Motors and Generators--I

By A. A. Fredericks

SYNOPSIS—How new conditions of voltage or speed may be met by reconnecting the armature windings.

Rewinding a generator or motor for a different voltage, the speed remaining the same, for the same voltage at a different speed, or for a voltage and speed different from those for which the machine was designed, are problems that sometimes confront the electrician. In many cases the change can be made without rewinding the armature or field, or at most rewinding one or the other only. In this article will be given an explanation of the different types of windings and the various ways of grouping the coils on the armature and some examples of what to do to meet certain requirements.

Everything else remaining constant, the voltage of a direct-current generator varies directly as the number of conductors in series on the armature. For instance, on a given 125-volt armature there are 75 conductors in series per circuit between the brushes. If it is desired to have the machine generate 250 volts it will be necessary to double the number of conductors in series or connect 150 in series between the brushes. The same condition holds true for a motor, and if the voltage at which the motor is working is changed from 125 to 250 volts the number of conductors in series on the armature must be changed in direct proportion to the voltage. Increasing the speed of a generator increases the voltage and capacity in direct proportion.

For a motor, where other factors remain constant the speed and capacity vary inversely as the number of conductors connected in series on the armature. To illustrate: If with 164 conductors in series between the brushes the speed of a 2.5-hp. motor is 500 r.p.m. and the number of conductors in series is reduced to 82, the speed will increase to 1000 r.p.m. and the capacity to 5 hp.

In general, two types of windings are used on direct-current armatures—parallel, or lap, windings and series, or wave, windings. In the parallel connection, there are as many paths through the winding as there are poles, which requires a set of brushes for each pole. In the series-connected winding there are only two paths through the armature, irrespective of the number of poles; hence, only two sets of brushes are necessary. These are set one pole space apart, irrespective of the number of poles, but usually a set of brushes is used for each pole, especially in sizes of 10 hp. and above. One circuit of a single, or simplex, lap winding is shown in Fig. 1, and for the purpose of comparison consider it one circuit of a 4-pole, 25-coil winding, although it might be one circuit of a parallel winding for any number of poles. The circuit through the winding and the way the coils overlap may be readily understood by referring to the figure.

In Fig. 3 is illustrated one circuit of a 4-pole, 25-coil, single, or simplex, series (wave) wound armature. In this type of winding there are only two circuits through it irrespective of the number of poles, as it will be noted that the winding progresses around the armature in a series of zigzag lines, or waves. By tracing out the circuit in Figs. 1 and 3 it will be seen that there are twice as many coils in series between the brushes in Fig. 3 as in Fig. 1; therefore, if the winding in Fig. 1 generates 110 volts, that in Fig. 3 will generate 220 volts under similar conditions. This also holds true for a motor; if the speed of the armature is 1000 r.p.m. on 110 volts with the winding connected as in Fig. 1, it will run at the same speed on 220 volts connected as in Fig. 3, other conditions remaining the same; or if it runs at 1000 r.p.m. on 110 volts with the armature winding connected in parallel, it will run 500 r.p.m. with the armature winding connected in series. In the latter case the capacity will be one-half that of the former.

This ratio of 2 between the parallel and series winding is true only for a 4-pole machine. On a 6-pole machine it is 3 and on an 8-pole machine, 4, etc.; in other words, it varies as the number of poles divided by two.

Fig. 2 shows a double, or duplex, parallel winding in which two circuits are in parallel between the brushes. In Fig. 1 there are six coils in series, whereas in Fig. 2 the six coils are connected so as to form two groups of three in series between the brushes, thus providing another means of varying the number of coils connected in series in a given armature. If a given winding is connected as in Fig. 1 to work on a 240-volt circuit, it may be connected as in Fig. 2 to work on 110 volts. In the single parallel winding of Fig. 1 the coil leads come to adjacent segments, for instance, the leads of coil *a* terminate in segments 1 and 2; but in the double parallel winding the coil leads terminate in alternate segments, as in Fig. 2, where the leads of coil *a* are connected to segments 1 and 3.

The winding in Fig. 4 is a double, or duplex, series winding having two groups of coils in parallel per circuit through the armature. In Fig. 3 there are twelve coils in series, whereas in Fig. 4 there are two groups of six coils in series. This furnishes another scheme of altering the winding connections for changing the voltage ratio by 2. On a 4-pole machine the voltage may be varied by 4 by changing from the connections of Fig. 3 to those shown in Fig. 2; for in Fig. 3 there are twelve coils in series between the brushes and in Fig. 2, three coils in series.

Any number of coils may be connected in either a single or a double parallel winding. A series winding can be used on multipolar machines only, but is rarely used except on four- and six-pole machines. The number of coils that can be connected in a single, series winding must satisfy the formula, $C = \frac{P}{2} S \pm 1$, and in a double, series winding, $C = \frac{P}{2} S \pm 2$, where C is the number of coils, P the number of poles, and S the pitch of the winding, that is, the number of segments spanned by the leads of one coil, which in Fig. 3 is 12.

From these formulas it will be found that only an odd number of coils can be wound in a 4-pole, single, series winding and an even number in a 4-pole, double, series winding. For this reason a 4-pole, double, series winding is seldom, if ever, used, the single, parallel winding being used instead and giving the same results. In examples given later it will be shown that the double, series winding is one of the easiest ways that the number of conductors in series in a 6-pole single, series winding can be cut in half, and in this respect is important. In Fig. 4 it will be seen that one coil has been added to that in Fig. 3, but one, as in Fig. 4, where coils *a* and *h* terminate in segments 4 and 6.

Where a double, parallel or series winding is used the brushes must be thick enough to rest on at least two segments, as shown in Figs. 2 and 4. Parallel and series windings may be connected triplex or quadruplex, although these are seldom used except on very low-voltage machines. Unless the brushes fit the commutator properly multiplex, parallel or series windings will cause more serious sparking at the commutator than single, parallel or series windings. If there is an even number of coils

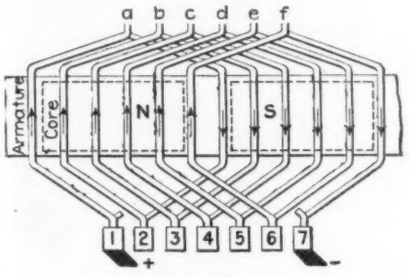


FIG. 1

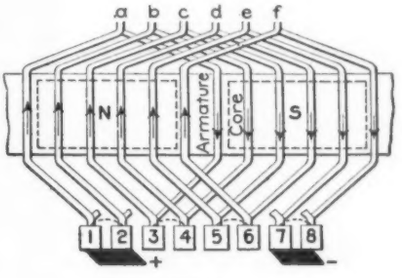


FIG. 2

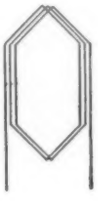


FIG. 5

FIG. 6

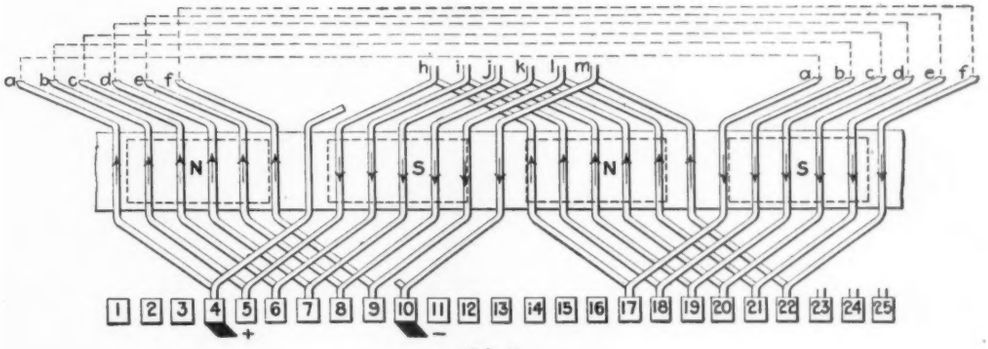


FIG. 3

FIG. 7

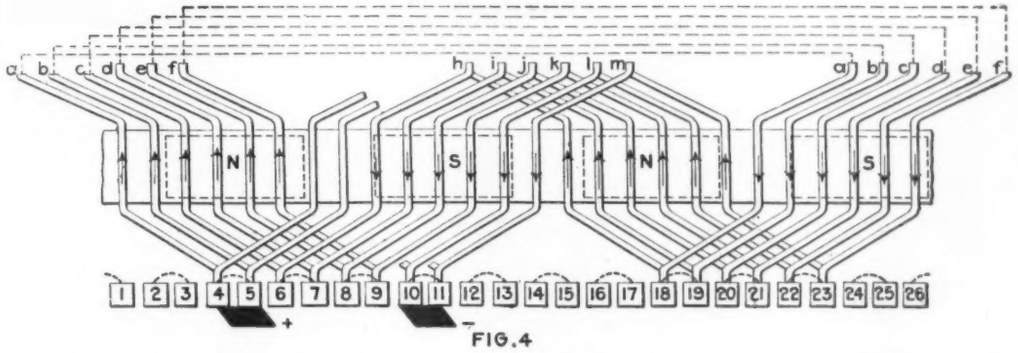


FIG. 4

FIG. 8

FIG. 1. SINGLE LAP WINDING. FIG. 2. DOUBLE LAP WINDING. FIG. 3. SINGLE WAVE WINDING. FIG. 4. DOUBLE WAVE WINDING. FIGS. 5 TO 8. SPECIAL COILS

as 25 coils will not wind in a double, series winding. If for any reason it is necessary to connect a 4-pole, single, series winding into a double, series winding one coil could be left dead. The coil was added in Fig. 4 for simplicity of illustration only.

In the single, series winding a series of $\frac{P}{2}$ coils, after encircling the armature, terminate in adjacent segments, as coils *a* and *h* (Fig. 3) which terminate in segments 4 and 5. In a double, series winding a series of $\frac{P}{2}$ coils encircle the armature and terminate in adjacent segments in a double, parallel or series winding the commutation can be improved by connecting adjacent segments as shown by the dotted line in Figs. 2 and 4. The windings in Figs. 1, 2, 3, and 4 have only one turn per coil and are usually made up of a copper bar bent the proper shape and insulated. The number of coils have been chosen with the idea of showing one circuit through the winding in the simplest manner.

Instead of the coils being wound with one turn, as shown in Figs. 1-4, they may, especially in small machines, be wound with several turns of a single conductor, as in Fig. 5. In this case the number of turns per

coil may be changed, as well as the scheme of connecting the coils to the commutator, to meet various voltage or speed requirements.

Another type of coil is shown in Fig. 6, where there is one turn of two conductors in parallel. A winding of this type can be easily changed for double voltage by connecting the two turns in series, as in Fig. 7. Fig. 8 represents a coil made up of two turns of two conductors in parallel. The type shown in Figs. 6 and 8 is used in low-voltage windings where the cross-section of the copper becomes too great to be conveniently formed or where using one conductor of the proper cross-section will not wind economically in the slot space.

By keeping the foregoing schemes in mind when a motor or generator is required to work on a different voltage or run at a different speed, the new condition can usually be met by reconnecting the armature winding. If the voltage is changed the field coils will have to be reconnected or rewound to meet the new condition.

Gifford-Wood Bucket Conveyor

The standard type of bucket conveyor manufactured by the Gifford-Wood Co., Hudson, N. Y., can be installed for handling both coal and ashes. It is designed for any capacity and to meet any conditions. The malleable-iron buckets are supported by large self-oiling rollers and are dumped by means of a traveling tripper that provides for the discharge of material at any point. The chain that carries the buckets has a short pitch, giving an even motion over the sprockets.

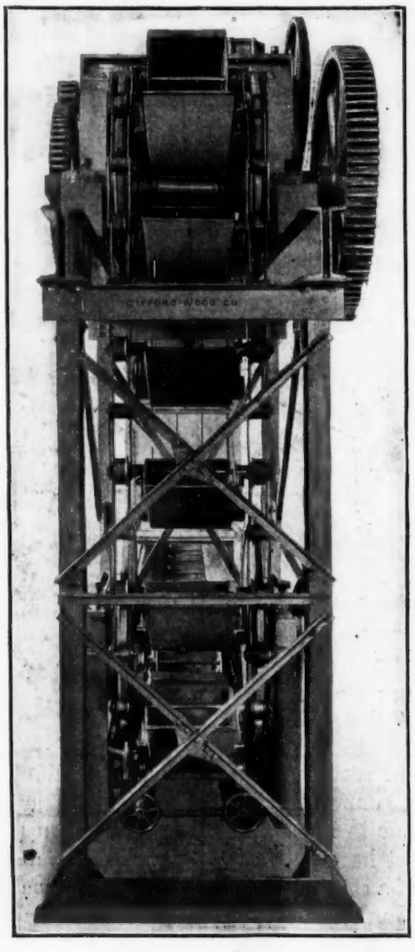


FIG. 1. DRIVING MACHINERY

The driving machinery, Fig. 1, is mounted on two side frames. The motor is on a double steel plate supported by two cast-iron bridge castings that also tie the two side frames together. The driving sprockets are provided with 12 chilled teeth, and every other one carries a driving knuckle. This gives the advantage of a short-pitch chain, and at the same time does away with equalizing gears and pinions.

As the buckets leave the wheels at the take-up corner, the position of the overlap is changed by a chilled cam secured to the floor, in order that they may ascend the vertical run at the far end in their proper position. After the buckets leave the cam they are guided under the trough by means of the bent pieces, Fig. 2. The trough extends on each side of the conveyor the length of the boiler room, pit or tunnel, and protects the chain from contact with ashes.

The pins passing through the bucket bushings are flat on one end, which prevent them from turning in the links,

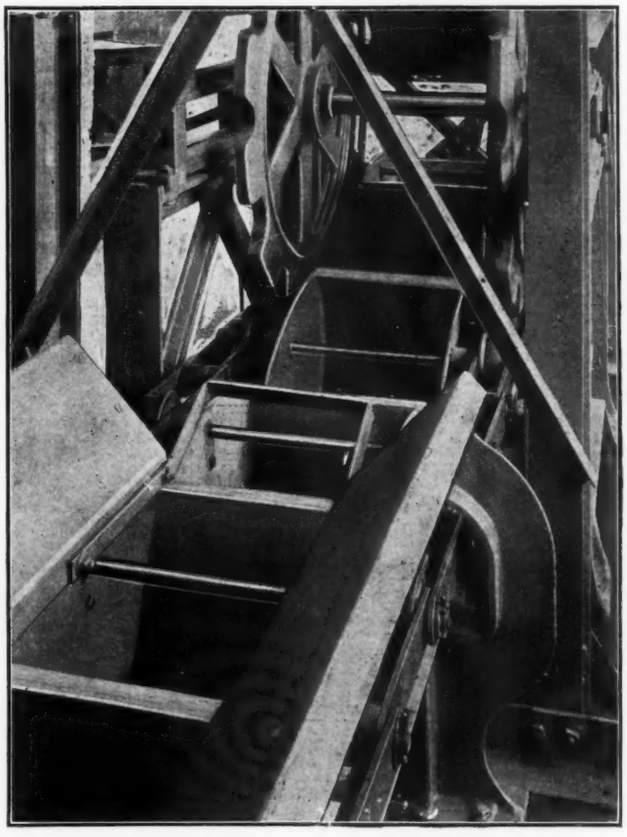


FIG. 2. BUCKETS AND PROTECTING TROUGH

and they turn in the bushings only when going over a sprocket. A felt washer is used in the oil chamber inside the roller to take care of the wear between the roller and the bushing. Each roller is provided with a small spring oiler.

The traveling tripper is moved by the action of the machine by means of a wire rope and winch operated from the boiler-room floor and provided with a ratchet and panel. The upper surfaces of the tripper are chilled and so shaped that the cams engage gradually, preventing shock and noise, and disengage as gradually after the buckets are dumped, preventing banging of the overlapping lips of the buckets when they come together.

Law of Resistance—Neglecting the temperature effect, resistance is directly proportional to the length and inversely proportional to the cross section of a conductor.

Where

R = Resistance in ohms;
L = Length of the conductor;
A = Area;
P = Constant for different materials;

then

$$R = P\frac{L}{A}$$

or the length of the conductor divided by the area and multiplied by the constant for the specific resistance of the material used, as found in any electrical handbook.

Gas Burners in 2750-Hp. Office-Building Boiler Plant

SYNOPSIS—An office-building plant in which the boiler furnaces are equipped for burning either gas or bituminous coal. The change from coal to gas can be made in thirty minutes, and from gas to coal in an hour. Owing to an extra large main the gas supply has always been sufficient for the demand.

One of the interesting boiler plants of Pittsburgh, Penn., is that of the H. C. Frick Building. There are five 550-hp. water-tube boilers, each equipped with 15 natural-gas burners placed above the firing doors. Fig. 3 is a view of the boiler room. The change from gas to coal can be made in about thirty minutes and from coal to gas in one hour. Special boiler fronts were made, so that coal can be used with the burners in place. A checker wall built in front of the gas burner is the only thing to remove when changing from gas to coal. The front and sectional views, Fig. 5, give the general dimensions of the furnaces.

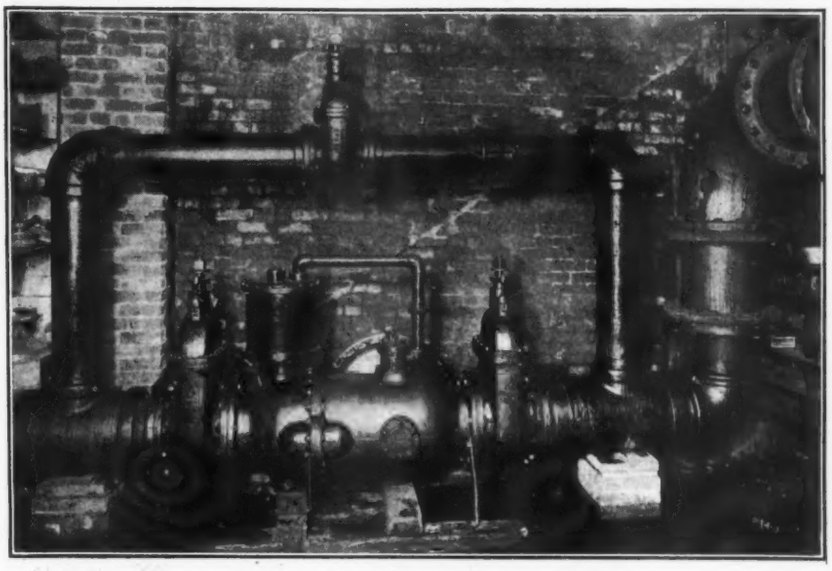


FIG. 1. GAS METER AND BYPASS

The Winner burners, put in by the Pittsburgh Reinforced Brazing & Machine Co., are placed in two rows for each boiler. In Fig. 4 is shown an exterior view of the burner. The front air shutter regulates the air intake; the connections at top and bottom are for the gas intake; the lever at the end of the large barrel is for increasing or decreasing the gas fed into the burner and the end cap is a supplemental air intake and burner cooler.

The gas enters either the top or the bottom intake, whichever is more convenient, the unused inlet being plugged. It is then fed to the chamber in the head (Fig. 6) and injected through ports into the rifles of the barrel, where it is given a swirl which mixes the gas with air entering through the center intake without retarding the velocity of the gas or reducing its pressure.

There are two sets of drilled holes in the rotatable ring shown between the large and the small drum—one set large, the other small. To expose the series of small holes, used on high-pressure gas, the lever (Fig. 4) is raised; to use the large holes, in case of low-pressure gas, the lever is lowered.

The piping of a gas-burning equipment is an important part of the installation. The area of the header at the burners should never be less than the combined areas of all the burners connected, and it is not a bad idea to have the supply main larger than the areas of the burners demand. In the Frick Building the gas comes from the street to the building through a 12-in. high-pressure meter and a 12-in. line, Fig. 1. The meter is bypassed by a 10-in. pipe connection. From the meter the gas goes to the boiler room through a 16-in. line. Here the pressure regulator, Fig. 2, operated from the main steam header, is placed in the 16-in. gas main in the depressed floor space in front of the boilers. The regulator is bypassed by an 8-in. pipe, so that in case of trouble gas can still be supplied to the burners. The main gas header is in a trench in front of the boilers, covered by the grating shown in Fig. 3, and branch lines go to the individual 12-in. headers, each branch being controlled by a gate valve, as shown. Gas goes to each burner through a 1½-in. pipe.

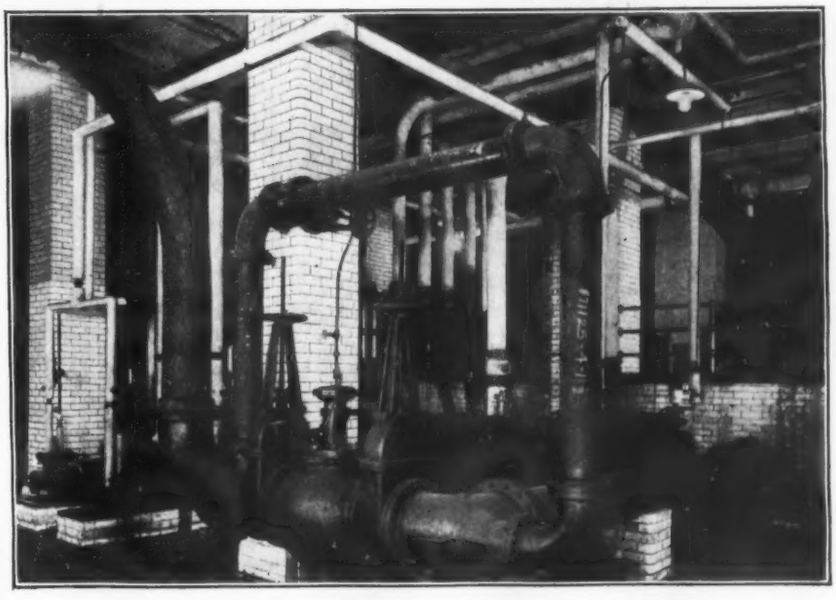


FIG. 2. GAS PRESSURE REGULATOR AND BYPASS

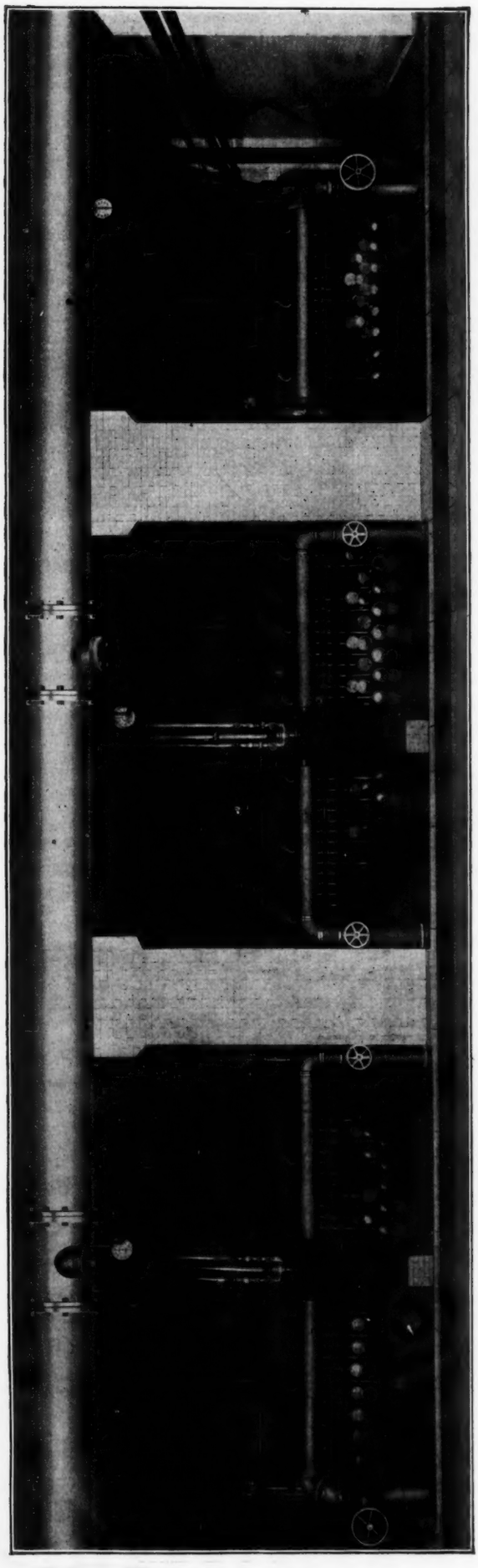


FIG. 3. BOILER ROOM OF THE H. C. FRICK BUILDING, SHOWING THE FIVE 550-HP. WATER-TUBE BOILERS EQUIPPED WITH OIL BURNERS

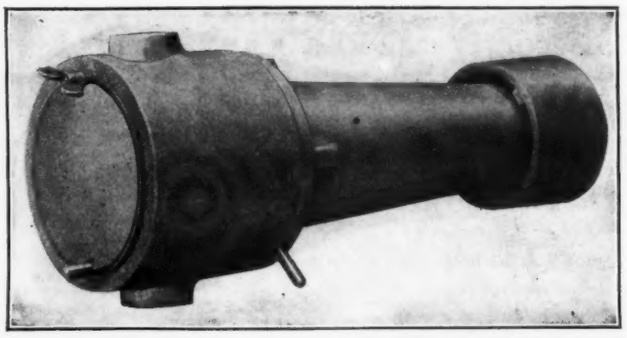


FIG. 4. EXTERIOR OF WINNER GAS BURNER

One advantage of the large supply line is that, no matter what the gas pressure in the street main, the supply has never failed, although it has been so low in near-by plants as to cause trouble. Gas will naturally flow through the pipe line offering the least resistance, and for this reason it flows to the boiler room of the Frick Building through the large supply main instead of to other plants in which it must flow through a relatively smaller pipe. The pressure at the burner is maintained at 6 oz.

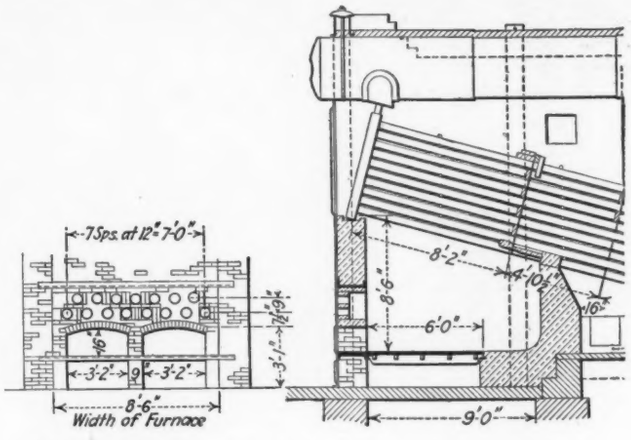


FIG. 5. FRONT AND SIDE ELEVATION OF BOILER EQUIPPED WITH GAS BURNERS

The appearance of the boiler room will be a revelation to most engineers on account of its cleanliness, the absence of coal and ashes, and the small amount of manual labor required. When coal was burned the consumption was 30 tons per 24 hr.; two firemen were employed on each 12-hr. shift and one ashman during the day shift. With gas as a fuel there is but one fireman on each 8-hr. shift, thus saving the wages of one fireman and the ashman. No figures of the operating costs are available, and although boiler-room costs are the important items, in this instance the absence of dirt, dust and ashes was to a great extent the deciding factor in favor of gas.

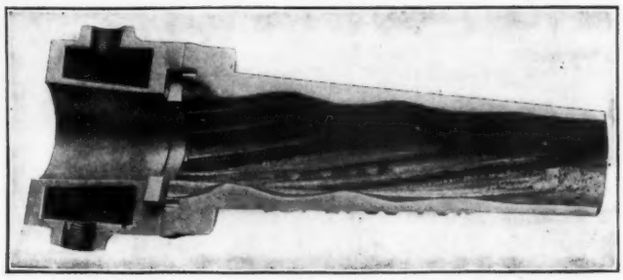


FIG. 6. SHOWING INTERIOR CONSTRUCTION OF BURNER

Wiegand Chain Screen Door

When a furnace door is opened cold air rushes in, chills the highly-heated brickwork and the boiler shell, causes contraction of the plate and lowers the temperature of the combustible gases. The heat radiated from the open door is a loss experienced with hand-fired furnaces. To overcome these objectionable features the E. J. Codd Co., 700 S. Caroline St., Baltimore, Md., has perfected and placed on the market a simple device known as the Wiegand

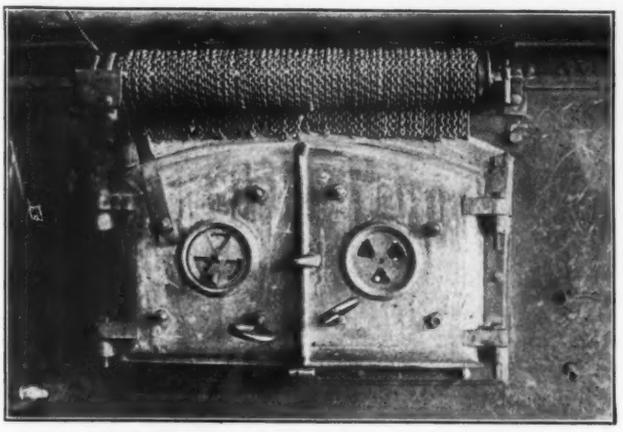


FIG. 1. CHAINS ROLLED ON THE CYLINDER

auxiliary chain screen door. It is designed to prevent the inrush of cold air upon opening the furnace door.

The chain door contains numerous, separately hanging strands of small steel chains, suspended from a cylinder extending across the top of the furnace door, with the chains hung as close together as possible, forming a continuous sheet. The cylinder carrying the screen is supported above the furnace opening by brackets. When the fire-door is closed the sheet of chains is rolled up on the cylinder (Fig. 1). The opening of the door automatically unrolls the chain and covers the opening (Fig. 2) preventing to a great extent the escape of heat and checking the entrance of cold air. The air that does enter

FIG. 2. LEVELING A FIRE WITH CHAINS UNROLLED

through the chains is split into small currents, which are heated before mingling with the gases escaping from the fuel bed.

This screen does not interfere with the handling of the fires, as may be seen in Figs. 2 and 3, where the fireman is shown leveling the fires and charging the furnace with fresh fuel, respectively.

An idea of the effectiveness of this device can be gotten from the result obtained by placing a thermometer 10 in. in front of the open furnace door. Without the screen in position the temperature jumped to about 400 deg. F. When the opening was covered by the screen the

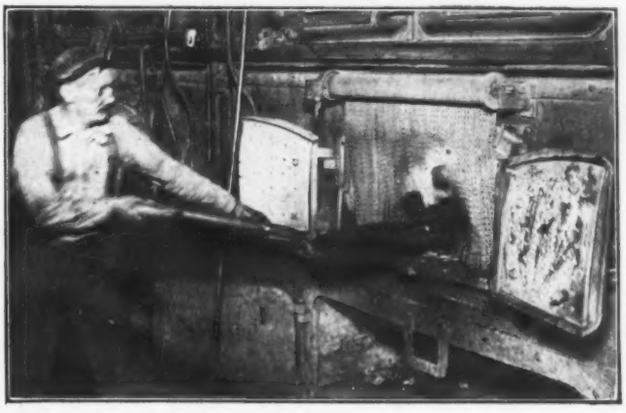


FIG. 3. CHAINS DO NOT HINDER FIRING

temperature registered 135, a difference of 265 deg. With the furnace door closed and the screen rolled up the thermometer showed 110 deg.

To Calculate a Pump's Duty

Find the horsepower required to operate the pump under the given conditions, which is the indicated horsepower of the steam cylinder and may be calculated from the work performed in the water-end of the pump, assuming for that purpose a mechanical efficiency of, say 75 per cent. Multiply this horsepower by 33,000 to reduce to foot-pounds per minute.

Now, find the heat units (B.t.u.) per pound of steam used in the cylinder each minute and multiply this heat value by the water-rate for the class of pump employed, and that product by the indicated horsepower, which will give the total heat (B.t.u.) converted into work each minute.

Finally, since this total heat energy is to be expressed in million B.t.u. when estimating the duty of a pump, multiply the foot-pounds of work performed each minute by 1,000,000 and divide the product by the total heat consumed in the same period of time. The quotient obtained will be the duty of the pump expressed in foot-pounds.

It is important to observe that the basis of estimating duty, in pumping practice, is purely an arbitrary one and varies greatly among engineers; so that it is necessary, in giving the duty of a pump, to state the basis of estimate employed. Otherwise, the duty given is of no value as demonstrating the efficiency of the plant.

Duty is very commonly estimated, as above, on a basis of million B.t.u.; or, as many engineers prefer, on a basis of thousand pounds of dry saturated steam consumed per unit of time. Aside from this difference, however the heat in the steam is sometimes taken as the total heat above 32 deg. F. and sometimes above the feed-water temperature. The latter method would seem to be preferable, inasmuch as it considers the ratio of the work performed to the heat in the steam derived from the combustion of the fuel in the furnace. It eliminates the heat imparted to the feed water by the condensation of waste steam in the feed-water heater. It may therefore be a latter index to the comparative cost of pumping, without confusing the efficiencies of the pump, boiler and furnace.

Assume that 25.6 hp. is required to pump 9000 gal. of water an hour, under an effective head of 502 ft., and assume a feed-water temperature of 100 deg. F. and the diameter of the steam-end double that of the water-end and find the duty of the pump, on the B.t.u. basis, above feed-water temperature.

The work performed is $25.6 \times 33{,}000 = 844{,}800$ ft.-lb. per min. When the pump is in operation the pressure in the water-end is $0.434 \times 502 = 217.8$ lb. per sq.in. The diameter ratio being 2, the required steam pressure is $217.8 \div 2^2 =$ say 55 lb. per sq.in., gage or $55 + 15 = 70$ lb., abs.

From steam tables, water at 100 deg. F. contains 67.9 B.t.u. and steam at 70 lb. abs., 1179.9 B.t.u., per pound. Since this pump uses 64 lb. of steam a minute, the total heat in the cylinder is $64\ (1179.9 - 67.9) = 71{,}168$ B.t.u. per min.

Duty of pump, $\frac{844{,}800 \times 1{,}000{,}000}{71{,}168} = 11{,}870{,}500$ ft.-lb.

—"Coal Age."

Model Boiler-Inspection and Engineers' License Law

At a joint meeting of the American Boiler Manufacturers' Association and the International Association of Tubular Boiler Manufacturers held at Pittsburgh on Mar. 29, for the purpose of furthering uniform boiler legislation and securing the adoption in all the states of the Boiler Code evolved by a committee of the American Society of Mechanical Engineers, a committee consisting of W. C. Connelly, president of the American Boiler Manufacturers' Association; C. V. Kellogg, president of the International Association Tubular Boiler Manufacturers; S. F. Jeter, chief engineer of the Hartford Steam Boiler Inspection and Insurance Co., and F. R. Low, editor of *Power,* was appointed to draw up a model law for the use of committees attempting to obtain such legislation. The form of law reported by this committee is here given. The numbers with which it is interspersed refer to a series of explanatory notes accompanying the report, which notes will be printed in a later issue. It is hoped that the model with its reference notes, which contain information as to numbers of inspectors and examiners employed, number of inspections and examinations made, salaries paid, penalties inflicted, exemptions allowed, etc., under existing laws, and other helpful suggestions, together with the digest of existing laws which will appear in the next issue, will be found useful by other committees in this field of endeavor.

Title (1)

An act to provide for the safe construction, use and inspection of steam boilers and power-plant apparatus; for a bureau of steam engineering and for the licensing of engineers.

Be it enacted, etc.

Appointment, eligibility and salary of chief inspector.

Section 1. Within ....(2).... days after the passage of this act and at any time thereafter that the office may become vacant, the governor (3) shall appoint (4) a citizen of this state who shall at the time of such appointment have had not less than ten years' practical experience as a boiler maker, boiler inspector or steam engineer (5) to be chief of the bureau of steam engineering, at an annual salary of ....(6).... dollars.

Duties of chief inspector.

Sec. 2. It shall be the duty of the chief inspector of the bureau of steam engineering, either personally or through his deputies and assistants, to inspect the design, construction, condition and installation of each boiler used or proposed to be used within this state, and if found suitable, to issue to the owner thereof a permit to operate such boiler, specifying the maximum pressure which it may be allowed to carry; to thoroughly inspect each such boiler internally and externally at least once in each calendar year (except that inspections made in the months of November and December will be considered as made in the succeeding year, and those made in January and February will be considered as made in the preceding year, but no period longer than 14 months shall elapse between two such inspections), and to inspect each boiler externally whenever he may deem necessary; to examine each person who is so concerned with the operation of a steam boiler or steam-using power-plant apparatus that lack of knowledge of and experience with such boiler or apparatus or of good judgment and dependability in the exercise of his duties in connection therewith might endanger the public safety, and if found competent, to issue to him a license to operate such plant; and to institute and conduct an investigation as to the circumstances and cause of every serious accident to a boiler or power-plant apparatus within the state, and report his findings to the governor.

Sec. 3. And said chief inspector of the bureau of steam engineering is hereby charged, directed and empowered:

Powers of chief inspector.

To establish and maintain the offices (7) necessary to the proper execution of the work of said bureau. To employ ....(8).... deputy inspectors of boilers and examiners (9) of engineers at a salary of not to exceed .... (10).... dollars per annum each. To employ stenographers, clerks and office help at an aggregate expense not to exceed ....(11).... dollars per annum.

To have free access for himself, his deputies or assistants to any premises where a boiler is being built for use in the state or where a boiler or power-plant apparatus is being operated under steam pressure, for the urpose of ascertaining if such boiler or apparatus is being built in accordance with the code referred to in Section 7 and safely operated in accordance with the previsions of this act.

To revoke and declare invalid a permit issued allowing a boiler to be operated or a license issued permitting its holder to operate a boiler or power-plant apparatus when in his opinion the boiler may not continue to be operated or the licensee to serve without menace to the public safety.

Powers of chief inspector.

To prosecute all violators of the provisions of this act.

To subpœna and examine witnesses with regard to the circumstances and cause of any accident to a boiler or power-plant apparatus and to compel the production of records, books, papers, instruments, etc., bearing upon the same.

To draw upon the state treasurer for funds necessary to meet the expenses authorized by this act, which, in addition to the salaries specified in Sections 1 and 3 shall include the necessary traveling expenses of the chief inspector and his deputies and assistants and the expenses incidental to the maintenance of the offices of the bureau, and to the conducting of investigations and hearings.

To prescribe and enforce rules and regulations for the conduct of his bureau and for carrying out the provisions and intent of this act not inconsistent with the constitution or with this or other acts of the legislature, provided that such rules and regulations shall not be in effect until approved by the governor (12).

To keep a complete record of the type, dimensions, age, condition, pressure allowed upon, location, and date of last inspection of all boilers to which this act applies within the state or to be used in this state and on all licenses granted to operatives.

Insurance and local inspectors.

Sec. 4. In addition to the boiler inspectors authorized by Section 3 of this act, the chief inspector of the bureau of steam engineering shall upon the request of any company authorized to insure boilers in this state, or of the official head of any municipal or county board legally authorized to inspect boilers or examine and license attendants in any municipality or county of this state, appoint any inspector or inspectors of said company or any examiner or examiners of such board or commission as special inspectors or examiners of the bureau of steam engineering, provided each such inspector or examiner has passed satisfactorily the examination pro-

vided for in Section 5 of this act; but such special inspectors or examiners shall receive no salary from, nor shall any of their expenses be paid by, the state, and the continuance of their commission shall be conditioned upon their continuing in the employ of the said company or municipality and upon the maintenance of the standards imposed by this act and compliance with the rules and regulations established by the chief of the bureau of steam engineering. Such special inspectors shall be required to inspect and report upon all boilers insured by their respective companies, or boilers the inspection of which is provided for by the law or ordinance creating their respective county or municipal boards, and such boilers only; and such boilers shall be exempt from all fees for state inspection and from all inspection other than that of the insurance or local inspectors except in such instances as the chief inspector may consider a special inspection necessary.

Sec. 5. Examination for inspectors' commissions and for licenses to operate may be oral, manual or written or any or all of these, but must be confined to questions and tests the answers to and execution of which will aid in determining the fitness and competency of the applicant for the intended service, and must be of uniform grade throughout the state (13). In case an application for an inspector's commission or an engineer's license, or for a renewal of the same, is refused by an examiner or examiners, the applicant may appeal to the chief inspector, who shall appoint two examiners other than the examiner or examiners who refused the commission or license or renewal, and upon the findings of the examiners on appeal, the chief inspector shall determine whether the license shall be granted or renewed. An applicant for an inspector's commission or an applicant on an appeal from an examiner's decision may have one witness present at his examination, who may take no part in the proceedings, but may take notes. At the request of an applicant, a verbatim written or stenographic record shall be made of his appeal examination, at his expense, and such record shall be accessible to such applicant and to the society, firm, corporation, county or municipality employing him. An applicant for an inspector's commission or license to operate may, if his application is refused after the appeal examination, or the holder of a commission as deputy inspector or of a license to operate may, upon the revocation of his commission or license by the chief inspector, appeal to .... (14).... and if this court shall find the refusal or revocation to be unwarranted or uncalled for by a reasonable regard to the public safety and the carying out of the provisions of this act, the court may grant the commission or license, or order the commission or license to continue, and it shall be recognized as valid by the bureau of steam engineering.

Examinations and appeals.

Sec. 6. On and after ....(15).... it shall be unlawful for any person, firm, partnership or corporation to operate in this state a boiler under steam pressure and subject to inspection as provided in this act, without a valid permit from the chief inspector of the bureau of steam engineering, or to operate a boiler or steam-operated power-plant apparatus mismanagement of which will be inimical to the public safety except in the presence and under the care of a person (16) holding a valid license from the chief inspector of the bureau of steam engineering. The operation of a boiler without a permit as above specified or at a pressure exceeding that specified in such permit, or the operation of a boiler or steam-operated power-plant apparatus as above described, except under the charge of a licensed attendant, or the assumption of such charge or the performance of such responsible service as above described by any person not holding a valid license from the chief inspector of the bureau of steam engineering and applying to such charge or service, shall be considered a misdemeanor, and be punishable upon conviction by a fine of not to exceed ....(17).... dollars or an imprisonment not to exceed ....(17).... days or both at the discretion of the court; provided, however, that in cases of emergency an owner or manager may allow a plant to be operated without a licensed attendant for a period not to exceed ....(18).... days; and an unlicensed person of presumptive competency may assume charge and perform the necessary services to keep the plant in operation for the same length of time.

Unlawful to operate without permit and license.

Penalties.

Sec. 7. On and after ....(15).... no boiler shall be installed in this state which does not conform to Part 1 of the Code formulated by the committee appointed for that purpose by the Council of the American Society of Mechanical Engineers, a corporation chartered under the laws of the State of New York, and approved by the council of that society on Feb. 13, 1915.

Code of boiler specifications.

Such boilers shall be inspected during construction by an inspector authorized to inspect boilers in this state, or if constructed outside the state they may be inspected by an inspector of an insurance company authorized to insure boilers in this state or by a state inspector of boilers in a state having boiler rules similar to those of this state.

All existing boilers shall be made to conform to the provisions of Part 2 of said Code and the formulas prescribed in such Code shall be used in determining the maximum allowable working pressure. (19)

Sec. 8. The owner or user of a boiler inspected by the bureau of steam engineering shall pay to the inspector ....(20).... dollars for each boiler internally and externally inspected, and ....(20).... dollars for each visit for external inspection. The inspector shall give receipts for the same and shall pay all sums so received to the chief inspector of boilers, who shall pay the same to the treasurer of the state.

The chief inspector shall further collect from each applicant for a license to operate or serve as attendant a fee of ....(21).... dollars, for an original license or a reissue involving change of grade or location and requiring a reëxamination and ....(21).... dollars for a renewal without examination. The funds so collected shall be turned over to the state treasurer, together with an itemized statement of their source (22).

Fees.

Sec. 9. This act shall not apply to boilers in the marine or railroad service and under the inspection of the United States Government, motor road vehicles, fire engines brought into the state in an emergency to check conflagrations, boilers in private residences, boilers in apartment houses occupied by not more than ....(24).... families; to heating boilers carrying pressures not exceeding ....(25).... pounds per square inch, nor having more than ....(25).... square feet of grate surface, or ....(25).... square feet of heating surface, except that boilers of this class installed on or after ....(15).... must conform to the requirements of Part 1, Section 2 of the Code described in Section 7 of this act.

Exemptions (23).

Sec. 10. The chief inspector of the bureau of steam engineering shall furnish a bond (26) in the sum of ....(27).... dollars, and each of the inspectors and examiners the appointment of whom is authorized by Section 3 of this act a bond in the sum of ....(27).... dollars, all conditioned upon the rendering of a true account of all moneys handled by them and upon the faithful performance of the duties of their office.

Protections against malfeasance.

Sec. 11. All acts and parts of acts inconsistent with this act are hereby repealed and this act shall take effect immediately.

Repealer.

Removing Scale from Ammonia Condensers

By A. G. Solomon .

SYNOPSIS—What the sump in the cellar is to its draining, what the sewer is to the building's sanitation, what the return tank is to the heating system—that, too, is the condenser to the refrigeration system. It is the place where all the heat taken up by the ammonia is delivered, so it can be finally transmitted to the atmosphere or carried away in the sewer. The importance of keeping it free from scale is evident. The article tells of some easy ways to remove scale and prevent its accumulation.

During the season's run of a refrigeration plant an accumulation of foreign matter in it will decrease its efficiency. Scale is the chief source of a lot of this trouble. The scale that forms in the boilers is so common and its effects so well known that it will not be discussed here.

Almost all water used for cooling purposes over the ammonia condensers will leave some deposit. Generally, this is first noticed as a green vegetable-like slime that collects in the water-distributing troughs over the coils.

It gradually works down over the coils and will be found to bake hard on the hot pipes where the hottest gas enters.

The best way to avoid trouble from this cause is to prevent the slime from accumulating. Have a hose connection and a long hose at the condenser, and wash out the troughs and the outside of the coils every day if necessary. This does not take long and is much easier than chipping hard scale.

How the Condenser Is Scaled

The writer has seen ammonia condensers, where the water was bad, become almost useless in a four months' run. At the beginning of the season these were new and the second pipe from the top was scarcely warmer than the cooling water leaving the condenser. The superheat of the gas was all taken out in the top pipe. In about a week this pipe was coated with a flint-like scale about $\frac{1}{16}$ in. thick. Now the superheat was taken out in the second pipe, and so on down, as each uppermost pipe was coated. These condensers were not even washed, and the effective cooling surface was gradually lessened until an expert engineer was called in to locate the trouble. When he arrived the plant had been in operation about four months, and the scale on the condensers was so heat-resisting that the ammonia traveled half-way down the condenser before it reached the temperature of saturation at the condenser pressure. The plant could not be shut down, but had to be kept going as best it could, even with the diminished capacity.

An Emergency Measure

The expert found three men who were willing to work on the coils, removing scale while the water was running over them. It took three weeks to clean the ten stands, and during the cleaning process one pipe was hit too hard and split, with the result that about a hundred dollars' worth of ammonia was lost. After these condensers were cleaned to the iron, they were washed twice a day with water from a small nozzle. The water pressure was 80 lb. The expert remained two weeks after the plant was operating satisfactorily and showed the manager and engineer that there was no excuse for allowing scale to accumulate.

Condenser Scale Removed by Reversing System

Another somewhat similar case was where each stand had a precooler of three lengths of pipe submerged in the condenser pan. After passing through the precooler the gas entered the top pipe of the stand and traveled downward. These pipes became coated with scale in a short time, and it was nearly impossible to get at them to clean. The condensers were built to handle the gas when all the cooling surface was clean and effective, but when the submerged pipe became useless the ammonia could not be liquefied. The scale became about $\frac{1}{8}$ in. thick and as hard as glass. A consulting engineer was called in, and he did a quick job of scale removing in the following way: It really amounted to just reversing the plant and using the ice tank for the condenser and the condenser for the evaporating coils. He allowed the condenser coils to become as dry as possible and then pumped them out and kept them frosted for about two hours. Then the system was changed back to the proper circulation, but the water was not allowed to flow over them. About one-half of the charge of ammonia was left stored in some of the ice-tank coils, and the rest was circulated fast, so that it heated the condensers to quite a high temperature. This reversing of the system was done four times, then the heavily scaled coils were hammered with a light hammer and the scale fell off. The alternate cooling and heating had cracked it loose from the pipe and it came off easily. This is a safe, quick and easy way to remove scale if it is hard. The writer does not think it will work as well on spongy scale, but it will do no harm to try.

Precautions Necessary When Chipping Scale

If the usual way of chipping and scraping the condenser coils is resorted to, care must be taken not to split the pipe by hard striking. If chipping hammers are used, do not have them sharp, as the pipe will be cut and scale will more readily form. The kind of rasp used by horseshoers is a good tool to use for removing thin, hard scale. Scaling tools operated by an air motor are also sometimes used, but should be used with care, owing to the hard, quick blows they deliver.

There are several condenser paints on the market that give excellent results with some kind of scale. These paints are thin and the scale that forms will stick to them instead of to the pipe, and light hammering removes both scale and paint. After clearing, the coils must be given another coat of paint.

Washing the condensers once or twice a day and brushing them with a stiff wire brush once a week will usually keep scale from forming; and even if an extra man has to be paid for this work, his wages will usually be more than saved at the coal pile.

Preventing Scale Formation in Double-Pipe Condenser

The double-pipe condensers are a little more troublesome to keep clean, but it is by no means impossible to keep them so. The water pipes of each stand must be provided with the necessary valves or three-way cocks so that the flow of water can be reversed and the sediment washed from top to bottom. With almost any cooling water circulated through the inner tubes, some sediment will be deposited. Therefore, they should be washed at least once a day. If hard scale forms it must be removed by a suitable scraper, drill or turbine tube cleaner. The return bends must be taken off at one end and the cleaning device forced through each tube. It is not a difficult job and should not be neglected. Set a certain day of each week for this work, and do not let anything interfere with its accomplishment.

If the condenser consists of a large number of stands a certain number can be cleaned each day, so that the whole condenser is gone over once a week or as often as required. A screen is almost an absolute necessity in the water line between the condenser pump and the double-pipe condenser. This screen is to prevent broken valve springs, valves and pieces of plunger packing from blocking the inner tubes.

If a cooling tower and reservoir are used, do not arrange the piping so that the discharge from the pump goes to the cooling tower and then causes the water to circulate through the condenser by gravity. Have the pump discharge through the condenser and then to the cooling tower. Gravity feed for the cooling water will not prove so satisfactory on a double-pipe condenser as it will on the atmospheric type.

Temperature Readings Desirable

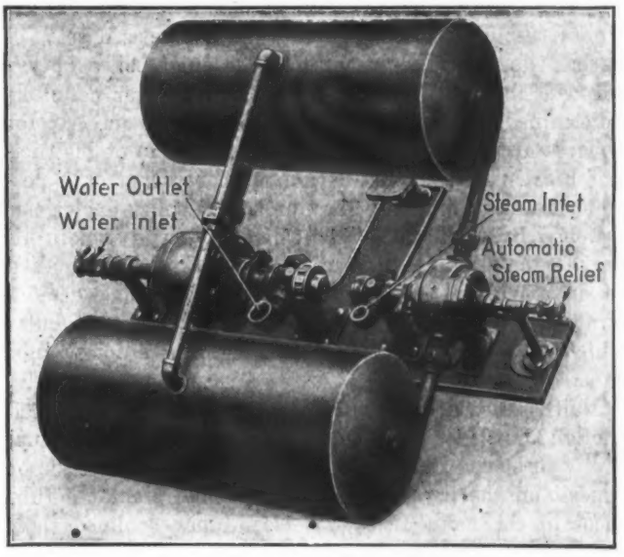
A good way to keep a record of the performance of a double-pipe condenser is to have suitable openings in the water-return bends at several different points, where thermometers can be inserted. This will show what each coil is doing. It is sometimes found that a few of the coils will be doing more than their share of the work and others will be doing little. The outlet-water valves must then be regulated so that all the coils have about the same temperature.

Temperature readings should be taken of the water as it leaves each coil of the atmospheric type of condenser. This temperature will often be found to vary several degrees on the different stands. The reason for such difference is that the water distribution is not proper or that the circulation of the ammonia is slower in some coils than in others. Regulating the flow of water will cause all the coils to work the same, and as this is what is desired, sufficient attention should be exercised to keep the condenser as effective as possible.

During cold weather such as we have in the North, it is generally necessary to pump out and shut off part of the condenser coils. If this is not done the liquid will often store up in one or more coils, and the ammonia which circulates will not be enough for the economic operation of the plant. The ammonia condenser is the part of the plant where the heat collected from the cooled rooms or coolers is given up to the water, and it should therefore be given the care that good practice demands.

The Duplex Steam Trap and Boiler Feeder

A duplex steam trap that will discharge water of condensation continuously is shown in the accompanying illustration. It is made up of two drums and is equipped with independent steam and water valves. The latter are operated simultaneously by the tilting of the drums. The drum in the up position fills with condensation. As soon as the weight is great enough it drops to the stop indicated in the photograph, raising the opposing drum and opening the water inlet to it. The same action admits



DUPLEX STEAM TRAP

steam to the top of the lower drum, which drives the water through the outlet. As the transfer from one drum to the other is rapid, the discharge is practically continuous. The valves are brass-lined to prevent corrosion and are of the sliding, self-cleaning type.

Water of condensation from any source may be collected and automatically discharged directly into the boiler or elevated into the heater at practically the temperature at which the steam is condensed. Continuous drainage insures dry steam in the system of piping to which the trap is connected. The trap is simple in construction, and the movement of the drums gives external indication that it is in working order. The Duplex Steam Trap Manufacturing Co., Moffat Building, Detroit, Mich., is the maker.

Air Required to Burn Fuel—To find the theoretical amount of air necessary to burn one pound of any fuel multiply 11.6 lb. (the weight of air necessary to burn one pound of carbon) by the percentage of carbon in the fuel, then multiply 34.8 lb. (the weight of air necessary to burn one pound of hydrogen) by the percentage of hydrogen in the fuel. The sum of these two results, disregarding the slight modification for the sulphur and oxygen, is the total air required when the gases are thoroughly united. A liberal increase of air amounting to 50 to 100 per cent. is found necessary in practice to obtain the best results.

Visits of Inspector Brown--I

By J. E. Terman

SYNOPSIS—Brown becomes a boiler inspector. He goes with the Chief, inspects three of six boilers, and recommends the removal of two circulating tubes in one of them. This later proved to have been unnecessary, which aroused the ire of the owner.

Brown was a young cub when he took up inspection work, and his youth was a handicap in a way, for boiler inspectors are rated on their experience, and although age does not necessarily betoken experience, the lack of it is looked on as an indication of inexperience.

Brown had the advantage of a college education, but like many others, he was without pull to aid him in getting a running start in life and had had several years of varied experience before he met the chief boiler inspector who finally employed him. It was never definitely determined just why the Chief took Brown on. At the time, it appeared that it was for the purpose of instructing him in boiler construction and operation as a possible means of reducing the number of boiler explosions.

When Brown first met the Chief, it was to explain his part in the attempted boiler repair which almost resulted in an explosion. The boiler on which he had demonstrated his lack of knowledge was a vertical tubular which had given trouble by leaking at the lower tube ends.

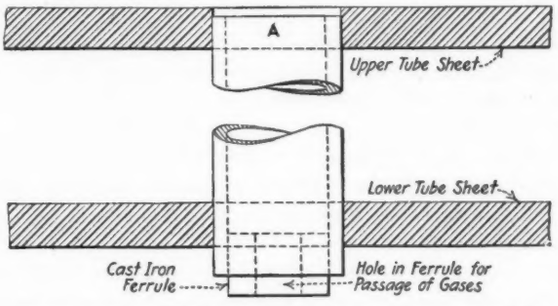
Neither Brown nor the chief engineer of the plant had enough knowledge of boiler operation to look for the usual causes of such a trouble on this type, such as oil, scale or deposit on the crown-sheet or tubes, and since the tube sheet in the main aisles was clean, they confined their attention to attempts to stop the leakage. Their efforts to this end were effective and the method of repair adopted was novel. It consisted of driving slightly tapered cast-iron ferrules into the tube ends, after it was demonstrated that rolling the ends of the tubes was without effect. This proved adequate so far as the stopping of leakage was concerned, and Brown began to think he might soon graduate as a full-fledged boiler-repair man. Then one day the fireman, who had been brushing the tubes, reported that they had pulled almost through the upper tube sheet. Upon investigation they were found to be about as shown at *A* in the illustration, and the Chief was sent for in a hurry.

With this introduction the Chief put Brown through the regular course of training by sending him out with the older inspectors to become familiar with the work, and to see if he indicated development of judgment as to what would constitute a dangerous defect in a boiler.

After several months of such tutelage, the Chief took Brown out to see how he would size up and to ascertain if he could be trusted to make inspections alone. The plant was in a mill and consisted of six Babcock & Wilcox boilers, all of which were to be inspected. Brown was assigned to the first three boilers, the Chief taking the others. After the inspection was completed, the Chief asked Brown what he had found. Brown reported among other defects of a minor nature two circulating tubes in No. 3, and then asked the Chief to go in and look them over to see if he thought they should be replaced. Brown was told that he had been inspecting long enough to be able to decide such questions himself and that if he was unable to do this he could never hope to become a boiler inspector.

Brown saw the point and decided to have another look before making up his mind about those tubes. After returning to the office he wrote his report on the three boilers he had inspected, one requirement calling for the renewal of two circulating tubes in No. 3 boiler.

About a week later, returning to the office one afternoon, he found the Chief and the mill owner talking to the manager in the latter's office. Being beckoned by the Chief, Brown entered the manager's office, whereupon the mill owner began to abuse and tell him how little



HOW THE TUBES HAD PULLED OUT OF THE TUBE SHEET

he knew about boilers and declared that time and again he had been put to unnecessary expense in removing the circulating tubes that were in better condition than those remaining in the boilers. Brown fully expected that if investigation should prove the mill owner's contention to be correct he would receive his walking papers.

The Chief had said little during the conversation, but had endeavored to encourage Brown by kindly glances, while the mill owner was ranting about the expense to which he had been put. Finally, Brown, thinking his case was hopeless and that nothing he might say could make matters worse, asked the owner why, if his engineer was so skilled in determining boiler conditions, he had not noticed that the tubes were not thin enough to require renewal before taking them out of the boiler, instead of making the discovery when it was too late to remedy the trouble. This question clearly gave the mill owner some trouble to answer, and his difficulty almost turned the Chief's broad smile into a laugh.

The manager, seeing that as a business policy, the arguments had best be stopped, instructed the Chief to make a thorough investigation of the complaint with a view to making a satisfactory adjustment with the owner.

The Chief took Brown to the mill the next afternoon, and upon examining the tubes that had been removed from the boiler, he found that the owner's contentions were in a measure correct and that the tubes were hardly thin enough to have required renewing at that time, although they were considerably corroded.

Completing his examination, the Chief asked the engineer the same question that Brown had asked the owner, as to why he had failed to note that the tubes were not so thin until after he had removed them from the boiler. Brown felt greatly relieved to hear the engineer state that he had thought the tubes were very thin until he had actually removed them and cut one open.

The Chief did not censure Brown for his mistake, but explained to him the difficulty of judging the thickness of tubes, and that they sometimes appeared soft and thin under the hammer, although only slightly corroded, as was the case in this instance. The Chief said that this would be a good lesson, but that he must not let the experience so react as to cause him to pass tubes in the future that were too thin to be safe. The Chief also gave Brown a first-hand illustration on the old tubes, of how the thicknesses might be better judged by using the peen of a hammer lightly, rather than by using the face, and explained how a strain on a tube, due to the weight supported, might cause it to sound altogether different from another tube when struck with a hammer, also the same effect being produced by scale on either the inner or outer surface of the tube.

Brown never forgot the lesson taught by this experience, and whenever it became necessary for him to condemn a tube on account of corrosion he made doubly sure that he had positive knowledge of its condition.

The Use of Superheated Steam

By L. P. St. Cyr

SYNOPSIS—An elementary treatment of the theoretical savings possible to effect in a plant by using superheated steam.

It often becomes necessary for an engineer to make a study of the advantages of using superheated steam. A few suggestions are here given as to the proper method of making a preliminary study of this problem with a view to finding out what saving, if any, can be expected by the use of superheated steam. Each plant has its own peculiar problems that must be studied at close range, but there are certain fundamental conditions common to every plant.

Superheaters are of two general types, direct-connected and independently fired. Direct-connected, or attached types, as they are sometimes called, are more common than independently fired, therefore this class alone will be considered here. Direct-connected superheaters are generally connected to the outlet for the saturated steam, which they conduct through tubes or coils, these coils being in contact with the hot gases, or in other words, constituting a part of the boiler. The addition of a superheater to a boiler means adding to the heating surface. This surface differs from the ordinary heating surface only in that the steam passing through the superheater tubes is not in contact with the water in the boiler.

There is no uniform practice as to the location of the superheater, for it depends to a large extent on the design of the boiler. The most common position, in a horizontal water-tube boiler, is between the tubes and the drum or drums. Sometimes the spacing of the tubes is changed so as to leave room for the superheater among them. Some superheaters are placed in a chamber formed in the side walls of the boiler setting, part of the boiler gases being bypassed through this chamber.

In boilers of the horizontal-return tubular and internally fired type the superheater is generally placed in the rear combustion chamber. The best location is open to question, but it is common to place it as far forward in a boiler as is possible without burning it. This gives a minimum amount of surface in the superheater per degree of superheat desired. Superheaters are sometimes placed in the uptake, or the flue leading to the stack. The advantage of this location as compared with one farther forward is that the gases have done all their work in the boiler and the heat taken from them is all gain. Another consideration is that it requires a minimum change to boilers already installed, as one superheater in the uptake can be made to take care of a number of boilers. The principal objection to a superheater in the uptake is that it is possible to get only a low degree of superheat, as the gases in the uptake are rarely over 600 deg. F. Also, the weight of a superheater per horsepower per degree of superheat obtained is greater than in any other location, owing to the small temperature difference between the steam and the surrounding gases. This will in most cases make the cost of a superheater prohibitive. Superheaters can be adapted to almost any type of boiler in service, with comparatively little change to the boiler or piping.

The location of the superheater having been decided upon, which in most cases will depend on local conditions, it is well to see what saving could be expected by the use of superheated steam.

In a general way we may say that steam superheated 100 deg. F. will give a saving over saturated steam of the same pressure of 10 per cent. in steam turbines, 12 per cent. in triple-expansion engines, 14 per cent. in compound engines, and 20 per cent. in simple engines. Therefore, to use a figure of 15 per cent. for the average plant with 100 deg. superheat is to be conservative.

Assume the efficiency of the boiler to be the same with superheaters as without and see what coal saving can be expected from 15 per cent. steam saving.

With this saving we will have

$$27.8 \times 0.15 = 4.17 \text{ } lb.$$

of steam only

$$27.8 - 4.17 \text{ or } 23.6 \text{ } lb.$$

of steam per horsepower will have to be superheated. The total heat per pound of steam superheated 100 deg. will be 1252 B.t.u. Therefore the total heat necessary to be added per horsepower will be

$$23.6 \times 1252 = 29{,}547 \text{ } B.t.u.$$

$$33{,}305 - 29{,}547 = 3758 \text{ } B.t.u.$$

saved per horsepower or a saving of

$$\frac{3758}{33{,}305} \times 100 = 11 \text{ } per \text{ } cent.$$

in the fuel for 15 per cent. steam saving. A steam saving

of 15 per cent. in the whole power plant does not necessarily mean that an equivalent amount of heat is saved in the boiler room.

When the location of the superheater is such that the heat required for superheating the steam is taken directly from the boiler gases, the saving will be as follows:

Consider a steam pressure of 150 lb. absolute, and assume 33,305 B.t.u.* as the heat equivalent of a boiler horsepower. The total heat per pound of steam will then be 1195 B.t.u. and the steam evaporated per horsepower

$$\frac{33{,}305}{1195} = 27.8 \textit{ lb.}$$

The heat necessary to add 100 deg. of superheat to this amount of steam will be

$$27.8 \times 57 = 1584 \textit{ B.t.u. per hour}$$

Therefore, the net saving will be

$$33{,}305 \times 0.15 - 1584 = 3412 \textit{ B.t.u.}$$

$$\frac{3412}{33{,}305} \times 100 = 10 \textit{ per cent. saving in fuel}$$

As most superheaters in horizontal water-tube boilers are placed between the drums and tubes where the gases do not strike the superheater until they have completed their work on the first pass, and as the greater part of their work in the boiler has been completed, there will be little loss in boiler efficiency, therefore 15 per cent. steam saving will represent nearly the same amount in coal saving.

Suppose the gases at the end of the first pass have a temperature of 900 deg. F. and leave the boiler at 550 deg. F. There is a drop of 350 deg. F. Take 2.5 per cent. as the calorific value of the coal absorbed by the boiler per 100-deg. drop in temperature, which is a conservative figure for ordinary practice. Then

$$3.50 \times 2.5 = 8.75 \textit{ per cent.}$$

of the calorific value of the coal only is absorbed by the last two passes.

Assume 4 lb. of coal burned per boiler horsepower and 24 lb. of air supplied per pound of coal burned;

$$24 \times 4 = 96 \textit{ lb. of gases per horsepower}$$

There will be, roughly,

$$900 \times 0.24 \times 96 = 20{,}736 \textit{ B.t.u.}$$

per horsepower in the gases at the end of the first pass and

$$550 \times 0.24 \times 96 = 12{,}672 \textit{ B.t.u.}$$

per horsepower in the gases leaving the boiler.

$$20{,}736 - 12{,}672 = 8064 \textit{ B.t.u.}$$

taken out of the gases in the last two passes, neglecting radiation losses. Therefore, if the superheater requires 1584 B.t.u., the loss in the last two passes will be

$$\frac{1584}{8064} \times 100 = 10.9 \textit{ per cent.}$$

assuming that the final temperature of the gases is not lowered by the addition of the heating surface of the superheater. Now, as only 8.75 per cent. of the calorific value of the coal is absorbed by the last two passes, the loss in boiler efficiency will be

$$0.109 \times 0.0875 = 0.95$$

or less than 1 per cent. It will be safe to assume that in general there will be not more than 1 per cent. loss in boiler efficiency due to installing superheaters in this location.

In the case of a new installation the size of unit to be installed can be fixed so as to take advantage of this saving quite readily. For an old installation it is more economical to run the boiler at its rated capacity when the additional heat units generated can be made use of in the power plant. Sometimes it is found that the saving due to superheat will allow of cutting out one or more boilers.

Considerable saving in a plant will be realized in the pipe lines when passing superheated instead of saturated steam, because the former has a much lower thermal conductivity than the latter. A higher steam velocity can be used in the pipes with superheated steam without increasing the drop in pressure. This will allow a saving in the cost of piping and decrease the loss due to radiation. In an old installation it is seldom desirable to alter the existing piping when installing superheaters, therefore the saving due to smaller pipes cannot be considered.

A point which must be carefully looked into when changing over a plant from saturated to superheated steam is whether the existing pipe fittings and valves are suitable for the higher-temperature steam. Much has been written regarding the advantages and disadvantages of cast iron and steel for fittings and valves with superheated steam, but there seems to be no general agreement on the subject. Cases have been cited of failures of castings where the final temperature of the steam was only 475 deg. F., while on the other hand there are doubtless many more plants using superheated steam equipped with cast-iron fittings and valves than there are equipped with cast steel. Those who advocate cast-iron fittings with total temperature of steam up to 500 deg. F. are nearly all agreed that the cast iron should contain a large proportion of steel to give it strength to resist expansion strains and should also be low in silicon; not to exceed 1½ per cent. of the latter element. The general trend seems to be toward the use of cast steel with any considerable degree of superheat and pressure.

The states of Massachusetts and Ohio and several cities, including Chicago and Detroit, have boiler- and superheater-inspection laws governing the use of cast iron or steel with superheated steam. These laws are quite uniform and specify that parts of superheaters under pressure shall be of cast steel when the working pressure exceeds 50 lb. Considering the number of plants now running on superheated steam where cast-iron fittings are used without giving trouble, it would seem safe to say that one would be taking little risk to change over any plant and use the existing piping with a final temperature of steam up to 500 deg. F.

Some engineers are prejudiced against superheated steam, fearing that it will be difficult to keep the piping joints tight and also that they will have lubricating trouble. The fact is that it is easier to keep superheated-steam joints from leaking than saturated, only care should be exercised in choosing the right kind of gasket and packing.

For lubrication a mineral oil should be used or a vegetable oil with a high flash point so that it will not be decomposed by the high temperatures obtained.

The saving in any plant will increase with the amount of superheat, but the amount that should be used depends on the type of prime movers. Turbines, for example, can use steam that is superheated to much higher temperatures than is practicable with most reciprocating engines.

*Using the Marks and Davis value of 970.4, the heat equivalent of a boiler horsepower becomes $970.4 \times 34.5 = 33{,}478.8$ B.t.u.—Editor.

Chart for Direct-Heating Requirements

By A. M. Daniels

It is frequently necessary to estimate approximately the boiler horsepower and the quantity of coal required to heat a certain building for a heating season. The accompanying chart has been constructed as an aid to approximate calculations in which the cubical contents are used as a basis. The Cubic Feet of Contents and Boiler-Horsepower curve has abscissas at the bottom of the sheet and ordinates on the left side. In constructing this curve, which is for direct heating in zero weather of a building in New York or a similar climate, we have allowed 100 boiler horsepower for each 1,000,000 cu.ft. of contents. For average winter weather, there will be required about two-thirds, and for a full heating season of 5700 hours about half of this horsepower. Where a heating and ventilating apparatus is installed an average of one boiler horsepower for each 7000 cu.ft. of contents will be needed.

The Boiler-Horsepower and Water Evaporated curve, which has abscissas at the top of the sheet and ordinates on the left side, is based on an evaporation of 34.5 lb. of water per hour. The Water Evaporated and Coal curves have abscissas at the top of the sheet and ordinates on the right side, and are plotted as indicated for 7, 8, 9, 10, 11 and 12 pounds of water evaporated per pound of coal. The Coal per Season and Coal per Hour curve has abscissas at the top of the sheet and ordinates on the right-hand side. In constructing this curve we have assumed that one pound of coal will be required for each cubic foot of contents of building for a heating season of 240 twelve-hour days.

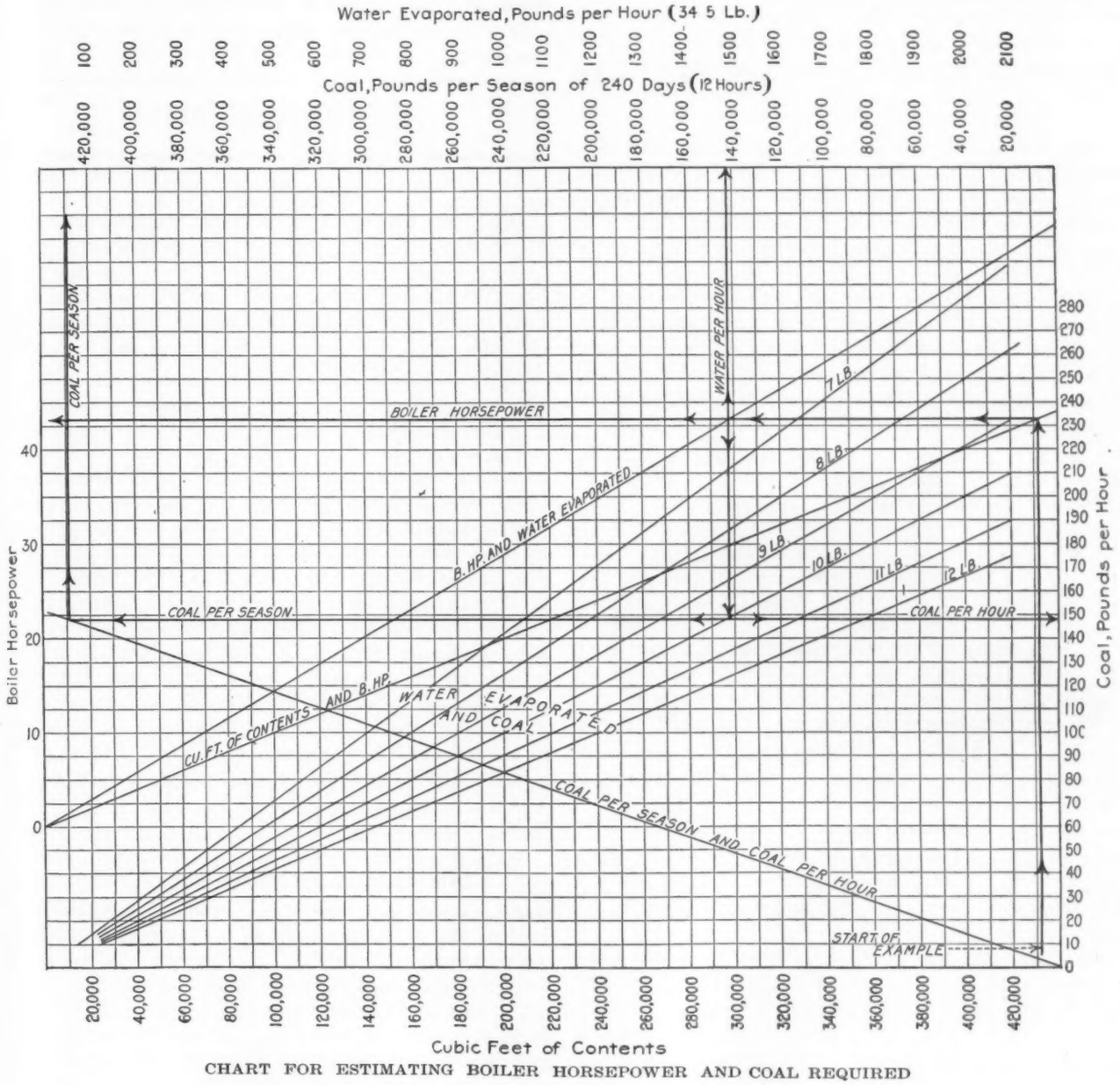


CHART FOR ESTIMATING BOILER HORSEPOWER AND COAL REQUIRED

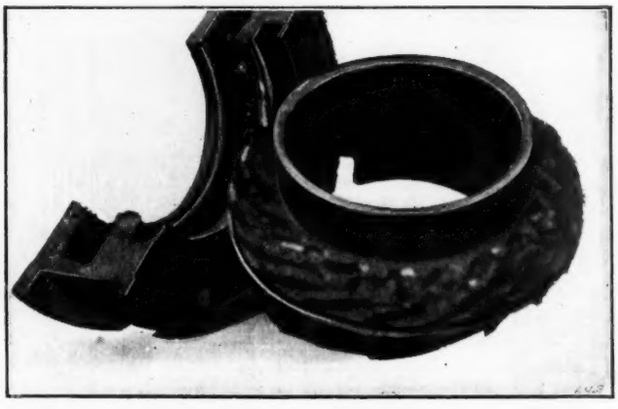
Suppose we must estimate the boiler-horsepower and the coal required per season to heat a building having 432,000 cu.ft. of contents. On the Cubic Feet of Contents scale we follow up the 432,000 ordinate to the Cubic Feet of Contents and Boiler-Horsepower curve. From this intersection we pass to the left of the sheet and read 43.2 on the Boiler-Horsepower scale. Where this line toward the left of the sheet intersects the Boiler Horsepower and

Water Evaporated curve, we move up to the Water Evaporated scale at the top of the sheet and read 1490 lb. per hour, or we may follow down to the Water Evaporated and Coal curve (in this case we have assumed 10 lb.), and from this intersection over to the scale of Coal-Pounds per Hour on the right of the sheet and read 149 lb. If we move to the left from this intersection until we intersect the Coal per Season curve, and thence up to the Coal per Season scale, we read 429,000 lb., the final result to be obtained from the chart.

Turbine Sealing-Water Trouble

By F. McGough

The sealing glands and paddle wheels of a 1000-kw. turbine, running condensing with a jet condenser, gave much trouble by becoming plugged with scale-forming matter deposited from raw water containing a large percentage of alkali. Condensed steam was finally substituted for this water. Copper coils were placed in the hotwell of the cooling tower and connected to the live-steam header. The condensate from these coils was then forced to a 20-gal. tank about 40 ft. above the glands and a float valve used to regulate the supply of condensate to the tank. This valve frequently "hung up," and unless the attendant was watchful of the altitude gage connected to the tank, he would lose the vacuum on account of lack of sealing water. After a while this valve was discontinued and the flow of condensate to the tank regulated by hand.



CORRODED PROPELLER

For a time this condensed steam seemed to work well, but the coils did not appear to be supplying enough water. It now became necessary to make a connection to the boiler-feed line, so that when the supply tank ran too low and the coils would not produce enough condensate, the water from the boiler-feed line could be turned on and the tank refilled. The boiler-feed water was taken from a heater and was therefore partly free from scale-forming matter.

One day the supply tank kept emptying itself faster than it could be filled. It was finally concluded that something was wrong with the glands and that the turbine would have to be dismantled to locate the trouble.

The casing was opened and the sealing glands and paddle wheels examined. Those from the high-pressure end are shown. The casing was deeply pitted, so deep in fact that in one place a hole ¼ in. diameter had been eaten through, while the paddles of the wheel (not so clearly shown) were almost all eaten off. The old casing was replaced with a new one and a phosphor-bronze paddle wheel took the place of the old one made of cast iron.

The turbine has been in constant operation eighteen hours a day for over a year since these repairs were made and the glands seem to be in as good condition as when first repaired. There is a noticeable decrease in the amount of sealing water required. The illustration shows the lower half of the sealing-gland casing and the paddle wheel with the inner side turned up. The break at the rear of the wheel shows where it was chipped to get it off the shaft.

JUST FOR FUN

Personal Safety First

One of the Hill editors is convinced that the safety-first movement is no new thing. In a notebook, written while in high school years ago, he hates to tell how many, is this: "In adding H_2SO_4 to chlorates always point the test tube toward the other fellow, not at yourself, as the chlorates often blow out the contents of the tube with explosive violence."—Editor.

Imagination Nearly Killed Him

The danger hidden in electric wires and cables was explained to a green helper, how his muscles would contract under certain conditions was impressed strongly upon his mind and that it would be sure death if he came in contact with a bare wire or connection. One day wild shrieks for help brought a crowd running, and the "green one" was discovered with his hands tightly clasped around a dead copper bar that had been used as a brace between two panels. He had stumbled and to prevent a fall, had grasped the bar, and imagination was doing the rest. "What in blazes is the matter with you?" asked the Chief. "I'm dying!" cried the victim. "I can't let go! I'm being electrocuted!" "Come off!" said the Chief, "that is not an electric connection and is not charged; its only a brace. Let go!"—J. E. Noble, Toronto, Ont., Can.

Plug in Tube Not Considered Proper

An inspector was called to examine an old boiler operated by the Italian foreman of a construction gang in Massachusetts. It had been bought second-hand a short time before, and all the tubes in the outside row except one appeared to be extremely thin. This one he thought to be the extra heavy one required for the fusible plug and started to take out the handhole plate opposite to examine it. The foreman asked:

"Why you make bother take dat out?"

"Oh, I want to examine the fusible plug."

"Fuse plug, fuse plug—I no understand fuse plug."

By this time the inspector saw that the tube was new and that the fusible plug was missing.

"How does this boiler happen to have only one new tube and no fusible plug?"

"Why, wen I first get da boiler, da boss tell me tubes no much good, soon mus' have new. I tak' off han' hole plate and see one tube with roun' plug. Dat no way fix such hole in tube, so I put a new tube in."—Stanley P. Stewart, Worcester, Mass.

Editorials

Capitalizing Mistakes

It has been well said that the man who never makes a mistake never makes anything. There are few places where a mistake may cause more trouble than in a power plant, but no matter how careful he may be, the engineer sometimes does things that are wrong from the standpoint of economical or safe operation. Since no one is infallible, the important thing is to guard against repetitions of mistakes.

With a proper plant organization and sound licensing laws strictly enforced, the chances of making dangerous mistakes are comparatively few. Errors of judgment in handling minor equipment are committed now and then and sometimes partially interrupt the service, but serious mishandling of main units is not to be expected where the chief engineer exercises his full responsibilities, trains his subordinates how to act in his absence and closely controls the staff and equipment under his executive direction. Under such conditions the errors of new men are almost sure to be confined to such as result only in temporary waste or in small failures of minor equipment which can be quickly repaired or readjusted.

Whenever an operating man realizes he has made a mistake he should seek its cause. Any attempt to forget or conceal it is poor policy. A frank discussion of a mistake, at the proper time and place, sometimes throws an immense amount of light on a range of operations which might otherwise go technically unappreciated for months. The engineer can pattern here from certain telephone and electric-lighting companies that publish in their monthly journals the lessons of various "fall-downs" in their work.

It is not necessary to call the attention of one's superior to trifling blunders. Too rapid running of the coal conveyor may perhaps lead to a hot box in the motor bearings. A well-regulated station will provide a place for recording this on the log sheet, and a frank admission that one was at fault in this connection will not necessarily injure one's good reputation if the thing does not happen twice. On the other hand, a slight drop in steam pressure through too rapid feeding of the boiler pumps may at once be recognized by the water tender as a mistake, but it may not be necessary to discuss the matter with the chief, or again, it may be helpful so to do. What is really necessary is to take every means of avoiding making the same mistake a second or a third time; for there are some errors of judgment, such as poor control of condensing equipment, which may occur even twice without affording ground for condemning an operator as unfit for his job.

A broad man not only learns from his own mistakes and from the errors of others, but is willing that others should learn from his. Young men especially need as much instruction on how not to do things as on how to do them, and it is no exaggeration to say that many an executive holds his position because of what he does not do quite as much as on account of his positive actions. Among friends, there is nothing more helpful to the engineer than to handle one's own mistakes in practice without mercy, becoming one's own severest critic and pointing out for the benefit of others how trouble arose from this or that mistake of judgment or hasty generalization. The more careful a man is to avoid mistakes in little tasks around the plant, the less likely is he to jeopardize the safety and efficiency of the service when given larger responsibilities. Rigorous self-examination is invaluable in this connection.

Incompetence and Carelessness

In fixing the causes of industrial accidents, too little distinction is made between incompetence and carelessness. An employee may be endowed with considerable native ability and yet be ignorant of the right performance of his duties; or he may be ever so able and well-grounded in those duties and still fail to properly perform them by reason of his ingrained carelessness.

That the workmen's compensation laws of the several states have done excellent work in caring for the injured is undeniable. Nevertheless, accidents are far too frequent and many of them are traceable to the hiring of incompetent rather than careless men.

It has been suggested that the accident hazard would be greatly reduced if money prizes were offered by the state to those companies which show during the year the greatest decrease in accidents caused by direct carelessness, the prizes to be distributed among safety committees, workmen, etc., in proportion to the service rendered in preventing accidents. By this plan, it is contended, the workman will be incited to coöperate with the company in its intention to lessen his chances of injury.

It is doubtful if such a plan would attain the desired end. While the chance to acquire a substantial money prize might fire the ambition of the fairly competent man to become ceaselessly vigilant in a hazardous occupation, still, if he were hired to perform duties of which he had only small knowledge, no prize incentive could guide him in times when quick judgment and ripe experience were demanded. Nor should his inexperience be held against him when it was the duty of those over him to make sure that he was capable of doing the work for which he was hired.

For example, two men undertake to clean a boiler. They attempt to remove the handhole plates before the boiler has been drained and are injured. The presumption is that, instead of being careless, they had not been properly instructed on how to clean a boiler; they had used all the care within their meager knowledge. And a power plant of all places has no room for the incompetent!

Many serious accidents can be indirectly traced to the extreme reluctance of the employer to hiring competent men—competent to perform many duties well and quickly. "You must keep down the power-plant labor

expense; hire the best men you can get for the least money!" Isn't this almost criminal policy the main promoter of accidents and incompetency?

Of what use is it for the employer to prate to his men that if they "want to be something more than common soldiers in the ranks of labor," they must put their "shoulders to the wheel and push, and push hard," and then, through the employees' necessities, force them to accept the common soldier's stipend? Mere platitudes in place of substantial wages are to our "soldier" just so much bunk and blunt his desire to do his best.

If, instead of "money prizes" as a means of lessening accidents, this employer will pay his men living wages, he will soon more than make up the added "expense" in larger returns of output, in more competent workmanship and in decreased carelessness and indifference.

Hydro-Electric Development in the West

Hydro-electric development in the states lying along the Rocky Mountains and west to the Pacific Coast is progressing with remarkable rapidity. Before many years it will be possible for almost all the railroad systems lying within these states to be converted from steam power to electric power. The recent opening of the Panama canal to shipping from Eastern supply depots to Pacific Coast ports will lend itself to the hastening of this conversion process inasmuch as every possible economy of transportation will be necessary to hold a fair share of the through business.

The development of irrigation in the arid sections has resulted in the bringing into being of many water powers not otherwise available, and their use in the supplying of electric current for local domestic purposes at once excites the traveler's admiration for the industry of the builders of these new communities. However, the increased saving where this power is employed for transportation should commend its use for that purpose.

Transportation is and has long been the one serious obstacle in the development of the Western states. It would seem that a power concession in favor of such purposes would be preferable to offering bonuses toward the construction of transportation lines. Such additional power as may then be necessary for local communities can be supplied by fuel brought in by the carrier at nominal rates. A stimulated freight service in many instances has been the means of saving a railway from bankruptcy, and in as many cases have development engineers found the local development of industry by their road to the mutual advantage of both road and territory served.

The Engineer and the Expert Witness

The increased interest of the public authorities in the broader problems of power production resulting from the spread of commission regulation and from the frequent appearance of consulting engineers in court cases means much to the operating engineer. Under present conditions, an engineer in charge of a plant may be called most unexpectedly to testify in connection with accident compensation, causes of service interruptions, observance of contracts by construction organizations and manufacturers, or in defense of his employer's policies in the way of charges for power supply or of plant expenses in relation to the issue of new securities. Probably no one is so well fitted as the operating engineer to meet the assumptions and contentions of the expert retained by his employer's opponent, which relate to plant service.

When called into such a case, for instance, the operating engineer will note in the testimony of the opposing expert where the plant was not gone over with sufficient thoroughness to enable an intelligent decision as to its value. Where his opponent makes a rough guess as to the cost of repairs per year on a certain piece of machinery, the engineer will be ready with a record showing just what it has actually been. When the specialist asserts that his observation told him that only one of the five units could be run in multiple with the incoming hydro-electric supply, the engineer will "come back" with a table of dates and hours when the layout "with one foot in the scrap heap" carried the entire local load of the system. And similarly in countless other ways the engineer may help the company's lawyer.

In brief, if the operating engineer called into such cases sticks closely to the field within which his practice has made him competent to handle many detailed problems of benefit to his employer, he can be a most important factor in the discomfiture of the opposition and increase his value to his employer.

A Model Boiler Inspection and License Law

The model boiler inspection and license law on page 82 is designed to avoid the difficulties which have been experienced with and which are feared from this class of legislation. Any attempt to require that all of the irresponsible help about a power plant be licensed, or, on the other hand, to have a blanket license in the name of one engineer for the whole plant, is precluded by requiring a license only for one "so concerned with the operation of a steam boiler or steam-using power-plant apparatus that lack of knowledge of and experience with such boiler or apparatus or of good judgment and dependability in the exercise of his duties in connection therewith might endanger the public safety"—but for all such. The freezing out of applicants by impossible examinations is provided against by requiring examinations to be practical and uniform, and allowing a candidate to have a witness or stenographer at an appeal examination with recourse to the court. Local boards already in existence are provided for by making them a part of the system while preserving their own autonomy. The head of the department is required to investigate every boiler explosion and serious accident to power-plant apparatus and attempt to determine the cause and fix the responsibility, which will have a deterrent effect upon the man who is inclined to take a chance. We shall be glad to have our readers' opinion of and suggestions concerning it.

Another state is on the Roll of Honor, that is to say, has adopted the A. S. M. E. Boiler Code. We are officially advised by the Department of Labor and Industry of Pennsylvania that the Industrial Board adopted the code May 26. This state's law empowers the board to fix its own rules regulating boiler inspection, so that the adoption of the code by this board is equivalent to its adoption by the state.

Correspondence

Making the Most of Efficiency Instruments

The editorial in the Apr. 27 issue refers to the report of the Committee on Prime Movers of the National Electric Light Association, which finds that "a feeling exists among power-plant owners that the use of so-called 'efficiency instruments' has been in a measure instructive, but that on the whole the results have been disappointing."

Does this mean that the committee considers that, in general, "power-plant efficiency instruments" are not paying a fair return upon the investment in them, or that the first estimates of anticipated savings were placed too high?

The writer is not convinced that the results have been disappointing. It is difficult to obtain opinions from enough engineers and owners on points of this kind to conclusively decide the question. Many plants have reduced expenses by applying the information from efficiency instruments, and on the other hand, some are overloaded with such instruments.

A point that has not received sufficient attention is the use of the information after it is obtained. It is not enough to take readings and make records without applying the information. The owner may ask the engineer, "What percentage will be saved by this instrument?" If the plant is already operating at maximum economy (a condition that seldom exists) no improvement will be noted after installing the instrument. However, applying the information secured in a very efficient plant will help in maintaining the efficiency of the plant at its initial high level.

Most plants can be considerably improved. The amount of improvement effected by an instrument will depend upon the character of the information furnished and even more upon the diligence with which it is used.

The number and kind of instruments selected should depend upon the size of the plant and the opportunity of the engineering organization to digest and apply the results. Even pressure gages and thermometers were once rare but, happily, are now found in every plant. All plants of over 500 hp. should have a few simple recording instruments, such as a recording-pressure gage, a recording feed-water meter on the main line and a watt-hour meter for the whole plant output. The percentage of returns will be less in small than in large plants, but even in a 500-hp. plant a 2- or 3-per cent. saving in coal means a satisfactory return on an initial investment of five or six hundred dollars for instruments.

An amusing instance of attempting to have too many efficiency instruments occurred in a plant already equipped with complete registering, indicating and recording meters on the two boiler-feed pump suction lines. It was actually proposed to install meters on the discharge lines. Fortunately the uselessness was pointed out in time.

Failure to apply the information obtained is frequently due to the lack of a systematic method. It is better to make one change at a time and note its effect than to make a number of changes without knowing which, if any, is responsible for better results. In a western Massachusetts plant the records from a registering-indicating-recording boiler-feed meter were studied as follows:

First, the regularity of boiler feeding was improved to obtain the best results from the heater. At first the chart was very irregular, but careful attention to this alone, and the education of the firemen improved the rate of feeding greatly. Next, different grades of coal were compared by noting the relative evaporative values of each. Enough has been done with these tests to indicate progress in coal selection. The third point to be taken up is the testing of different methods of firing. Another important source of waste to be eliminated will be determined by studying the effect of varying the thickness of fuel bed, the amount of draft obtained by using the tube cleaner at various intervals, the worth of different firemen, etc.

The entire program of power-plant betterment has not yet been carried out, but thus far the evaporation has been brought to nine pounds of water per pound of coal instead of eight—an improvement of 12½ per cent.

The same method of systematic study instead of haphazard attempts may be applied with the information obtained from almost any of the more important power-plant instruments.

ALAN A. WOOD.

Providence, R. I.

Compensators for Corliss Governors

From time to time articles are published describing some form of Corliss-governor compensator, and there seem to be differences in opinion as to the purpose of, and the advantage in, using such a device. According to my understanding, the purpose of such an appliance is to reduce the variation in speed between no load and full load, and no improvement in the sensitiveness of the governor to sudden changes in load should be expected.

The first apparatus of the kind to come to my notice was in 1893, on a pair of 30x72-in. Corliss engines driving a large cotton mill. It consisted essentially of a curved brass tube *A*, Fig. 1, mounted upon the rocker shaft and containing a brass ball *B* that was supposed to roll back and forth in the tube, according to the position of the rocker shaft.

A similar device used on a large compound Corliss engine made use of a curved track *A*, Fig. 2, mounted on the rocker shaft, on which ran a heavy weight *B*, with a deep groove in the middle that had its bearing on the track and rolled back and forth as the position of the governor changed.

About five years ago some interesting experiments were made with a compensator on a Corliss engine on which the drop in speed from no load to full load was objectionable. For experimental purposes, a somewhat

crude device was first made, which gave us some valuable information as to the nature of the action of the weight *B* and its effect upon the regulation. It was found possible to run the engine faster at full and overloads than at light loads. It was also found that while a certain weight proved best adapted to this particular governor, a change in the weight had less effect than a change in the radius of the track on which it ran. Furthermore, the device could be adjusted to give stable regulation with a drop of ¾ to 1 per cent., but with nearly flat or a rising characteristic, hunting was likely to occur,

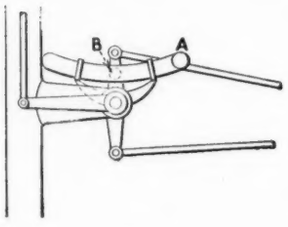


Fig. 1

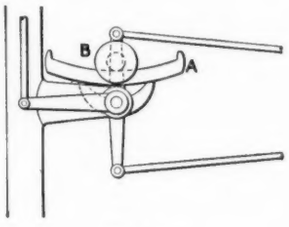


Fig. 2

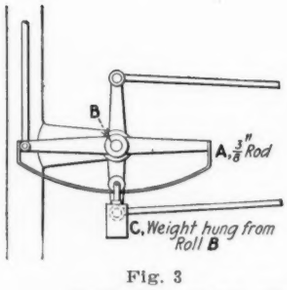


Fig. 3

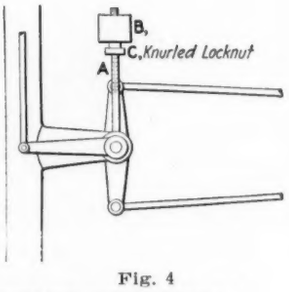


Fig. 4

COMPENSATORS FOR CORLISS GOVERNORS

the same as found in a shaft governor with too great a spring tension.

A weight attached to an inverted pendulum, Fig. 4, has also been employed to obtain a similar result, but so far as I know, it has not proved as satisfactory as other methods.

One thing my experience with such devices has indicated is that they are not of practical advantage in the case of an engine subject to frequent fluctuation of load of considerable amount, as on railway or rolling-mill load, because their effect must be made very mild or hunting will follow; but on an engine having a fairly steady load, with the changes occurring gradually, such a device will flatten out the curve on a governor otherwise giving poor regulation.

The principle involved is that of having a given weight automatically assume a certain position on a lever connected to the rocker shaft, which position bears a definite relation to the position of the governor in a way to augment or diminish the effect of the counterpoise weight of the governor according as the governor balls tend to fall below or rise above a given position.

A little consideration of the subject will show that the weight or mass of the moving weight would be determined by the amount of counterpoise weight to be affected and the travel allowed the moving weight, and that the radius of the curve of the member carrying the moving weight would be determined by the angular movement of the rocker shaft between the extreme positions of the governor. A small angular movement requires a longer radius and a larger one a smaller radius.

By so proportioning the radius of the weight-carrying member and the rolling weight that a given governor will have, for example, a rate of 1 per cent. drop from no load to full load, when a gradual change in load occurs, calling for either a shorter or longer cutoff, the angular movement of the rocker shaft changes the position, in or out, of the rolling weight. This is owing to its lying in a curved path, and so it partially compensates the change in speed required to change the point of cutoff.

If, however, the effect of the rolling weight be made too great or the change in load sudden and of considerable magnitude, then the weight will overtravel, making the cutoff too short or too long, as the case may be, for the load at the moment, causing a change in speed in the opposite direction which, through further movement of the governor to correct the speed, causes a reversal of the effect of the rolling weight.

This action will then gradually die down to normal if the device does not give too flat a curve of regulation. If the rate is too flat the hunting will continue to increase until some means are taken to steady the governor until an equilibrium has been established.

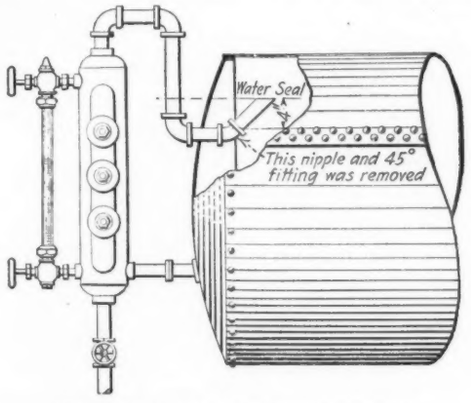
For this reason the device is not advantageous to use where there is a fluctuating load, but it is useful on such loads as are found in the average cotton or woolen mill or other plants having similar load characteristics.

CHARLES L. WARE.

Maynard, Mass.

A Water-Column Connection That Caused Trouble

I found this column connected, as shown, on a 400-hp. water-tube boiler. The top steam connection ran up about 3 in. and then down about 12 in. to the boiler connection. On the inside of the boiler there was a



ORIGINAL COLUMN CONNECTION

45-deg. fitting, with a short piece of pipe screwed into it and turned up to the top of the boiler. This formed a trap which held the water that collected in the pipe, causing the column to show a false level. This was a source of a great deal of trouble until the 45-deg. fitting was taken off, allowing the water to drain out of the pipe. While the water seal existed the indications were misleading, being sometimes too high (when the boiler water level was falling) and at other times too low (when the level was rising).

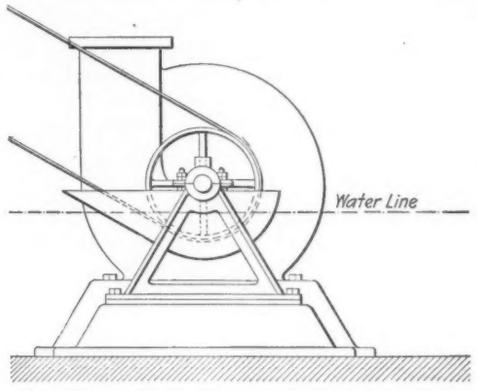
W. R. PENDER.

New Orleans, La.

High-Water Kink

A rotary pump to drain an open pit was presumably installed above high-water mark, but heavy rains and a break in the levee allowed the water to rise until about three inches of the bottom of the pump pulley was under water.

The motor which drove the pump was located four or five feet higher than the pump and was safely out of the



WROUGHT GUARDS PROTECTING BELT

water. In order to operate the pump the following plan was adopted:

A pan was made, as shown, and secured under the pump pulley in such a manner that the bottom of the pulley ran on the inside of it. The water that got into the pan while placing it was then bailed out, and the pump operated for several hours before the water level was below the belt.

EARL PAGETT.

Coffeyville, Kan.

Minding My Own Business (Not)

Occasionally, I notice, an engineer registers a kick against some particular job he is asked or expected to do. I believe that in a majority of these cases the engineer brings this work upon himself. Many are given to experimenting and trying new schemes without looking ahead to find out just what the ultimate result will be. A thing that looks pretty good today, with business quiet, may look like a mountain of work when your plant is working up to the maximum.

A simple case in my own experience will illustrate. A few years ago I was in charge of a small steam plant operated in connection with a carpet-cleaning business. At the end of each month the manager would bring the coal bill to the engine room and devote half an hour to kicking about the amount of coal used. At that time jobs were scarce, so it was a case of "sit tight, say nothing."

A lot of dust, etc., from the machines (tumblers, beaters, compressed-air blowers, etc.) was collected in the dust bins. In the course of a year it amounted to 25 or 30 two-horse loads, and its removal was quite an item of expense, besides being a bothersome job. Cleaning-out time was dreaded by the help in general.

One day a few barrels of this dust was dumped in the boiler room, and I found that a certain percentage of it would burn, but it would have to be handled just so, or it would put the fires out. With a reasonable amount of common sense, I would have refused to ever allow any of it to be brought into the boiler room again. Instead of this I began to burn the small amounts we were collecting in our dull season. In justice to myself my main idea was to try to cut a little off the coal bill and, if possible, to please the manager. It did please him, as we would save the cleaning of the bins.

As the spring advanced, the load and my other work increased, and I could not do this extra work. Besides, I found that it was saving nothing on the coal bill. Therefore I refused to have anything more to do with this dust proposition, and of course this resulted in a stormy session with the manager, during which I gave in my notice.

The engineer that followed me also quit as soon as the dust proposition was mentioned, as did his successor, and in the end things dropped back to their normal condition. How much better it would have been for all concerned if I had looked ahead or had ascertained the value of this dust as fuel by some simple experiments! I would have saved myself a lot of hard, useless and thankless work.

Saving money where possible is certainly the engineer's business and a duty that every one owes his employer, but he should be sure that he *is* saving money. If, however, he is fool enough to suggest ideas that make his job harder and more disagreeable, he certainly should not blame his employer.

A. D. PALMER.

Dorchester, Mass.

Uniform Size for Catalogs

I heartily indorse the sentiment of Lewis F. Brown, in the issue of June 15, page 821, as to the desirability of uniform size for catalogs. We have the same complaint to make. Different sizes not only make the files unhandy, but the appearance is anything but pleasing.

It might be difficult to have one standard size for all, but there should be no more than three standard sizes—small, medium and large (the same could also be very appropriately applied to books). It is to be hoped that some effort will be made in this direction before very long.

H. D. BEDINGER.

East Chicago, Ind.

Pump Valve Became Lodged in Venturi Meter

Upon opening a boiler-feed pump one 4-in. valve was found to be missing. A new one was put in, but it was noticed shortly afterward that the venturi meter in the feed line was not recording correctly and that about 20 lb. additional pressure was necessary at the pump to feed the battery of four 400-(rated) hp. boilers. To avoid shutting down before that "heat" was out of the iron furnace, which is a matter of importance in iron and steel mills, the feed pressure was increased and a close watch kept, but by the time the heat was out only one boiler had a normal water level and the others were damped on account of low water.

The pump valve was found wedged in the meter, and it required an iron rod to drive it out. To avoid another such occurrence a full-sized sheet-copper disk

drilled full of 5/8-in. holes, forming a strainer, was placed in the line near the pump. Incidentally, boiler-feed pumps should always be supplied with pressure gages to indicate what is going on inside.

A. E. Baker.

Cambridge, Ohio.

Adjusting Pumping-Engine Crank Bearings

In keying large vertical pumping engines one is confronted with certain difficulties not met with in smaller engines nor in those of the horizontal type. The combined weight of the moving parts often amounts to several tons, and unless some plan is devised to relieve the pressure, such as described in the issue of June 8, page 790, accurate adjustment of the wedge cannot be accomplished. Ordinary methods of testing the adjustment of the crank and crosshead bearings are not practical.

We keep a logbook of all such bearings, so that the operator may know how much to back a bolt off after having pulled it up tightly, but it is necessary to relieve the weight from the wedge, so as to insure freedom of action.

Edward T. Binns.

Philadelphia, Pa.

Engineers as Salesmen

The letter in the May 25 issue and the earlier editorial to which it referred, recall some of my experiences with salesmen—engineering and otherwise. I remember a young packing salesman who recommended a high-grade asbestos packing for a plunger elevator that was giving us trouble. Later, when something was said about packing for the valve stems, he asked what the valve stems were!

At another time a rope drive was required. Salesmen from two companies finally assured us that our proposed arrangement was impracticable. We were about to adopt another scheme, when a third salesman appeared. We told him it was no use, the thing could not be done, but he was from Missouri. He spent half a day taking measurements and two dayslater came in with a confident "I can." And he did.

Hearing with surprise, that a manufacturer of steam specialties no longer had a certain salesman, I remarked that I had heard that the fellow was a hustler. "I should say he was," he replied. "I think that fellow could sell five-dollar gold pieces for $7.49 each. Sell? I never had a man who could touch him at that game. But he overdid the thing. Fact is, I doubt if I shall live long enough to get out of the trouble he got me into. It mattered little to him whether an appliance suited conditions, his only object was to sell."

This brought to mind an agent who persisted in selling us a certain regulating valve. We assured him that his valve could not meet our conditions, but he could not see it that way. Wouldn't we let him put it in on trial? Finally, to get rid of him the order was placed. As we expected, the device was a failure and we proceeded to replace it. Then the company "squealed" on the trial, and there were acrimonious letters and unpleasant feelings. About six months later the question arose as to what make of valves to use in a certain installation of considerable size, and a valve made by the aforesaid company was one of those considered; but it was turned down mainly because of the unhappy incident related. While this was not all the fault of the salesman with the poor judgment, he started the ball rolling.

The "gift of gab" is undoubtedly an asset to any salesman, but other qualities are essential to success in engineering salesmanship. The man must know plants, must know the relation of other parts of the plant to the appliances he represents, and he must know his apparatus intimately. He should have had experience with things mechanical, so that he may use good judgment as to what is best fitted for given conditions. He must have imagination and insight enough to forecast the manner in which novel conditions are going to affect the goods he is offering, and he must have originality and training enough to enable him to suggest adaptations. The good salesman grasps conditions quickly, but does not jump at conclusions. Such a man soon inspires confidence.

Now these more important qualifications of the engineering salesman are right in line with the work of the wide-awake engineer. Suppose he does require a little time to develop a "presence" and a "line of talk." Can he not do that more easily than the talker can acquire engineering experience?

I am on the buying end. Most of the men whom I "swear by" came from the workshop and the engine room. Two of them are the poorest talkers ever, but excellent salesmen. Many concerns have already grasped this idea and are profiting thereby. There are other firms that would do well to think the matter over.

William E. Dixon.

Cambridge, Mass.

Tests of Cinder Concrete

Following is an analysis of the fire-resisting qualities of cinder concrete as a furnace lining where the direct heat does not reach it.

In going over a test of the fire-resisting qualities of different kinds of concrete made by a Hamburg commission, I found that a mixture of one of cement to seven or eight of coarse cinder gave the best results. This sample was repeatedly heated for 3¾ hours to a maximum temperature of 1080 deg. C. (1980 deg. F.) and then cooled, sometimes slowly and at other times quickly, and using the words of the report, it "was not broken; showed relatively the highest degree of coherence particularly in the center"; and when the sample was wetted after heating it "did not suffer."

The crushing strength of a 1 to 8 cinder concrete, according to Prof. J. B. Johnson, is 240 lb. per sq.in. With a mixture of 1 to 3 we get a crushing strength of over 900 lb. per sq.in. But the latter did not stand the fire test so well, for with a maximum temperature of 940 deg. C., its edges became "friable" when it was wetted after heating.

Comparing the strength of cinder concrete a month old with stone concrete of the same age, both 1 to 7, the former gave a crushing strength of 750 lb. per sq.in., while the latter gave a strength of 2400 lb. per sq.in.

Just what different effect a more prolonged heating at perhaps a lower temperature would give I do not know, nor could I find results of tests on this point.

A. R. Wells.

Blyth, Ont., Canada.

Inquiries of General Interest

Liberation of Oxygen by Electrolysis—What amount of oxygen will be liberated from water, per ampere-hour, by electrolysis?

N. A. W.

The oxygen liberated per ampere-hour will amount to about 0.29854 gram.

Electric Shock Depends on Voltage—Will a person receive a greater shock from touching a wire carrying 100 amp.than if the wire carries only 1 amp.?

Q. W. D.

If the voltage is the same no greater shock will be experienced in one case than in the other.

Inspection of a Boiler—When should the inspection of a boiler begin and when should it end?

W. M. S.

Inspection should begin with the manufacture of the material of which the boiler is constructed. Inspection should also be made during construction of the boiler and its condition should be inspected at frequent intervals down to the time when it is permanently discarded.

Relative Value of Upper and Lower Tubes—Are the tubes in the lowest row of a horizontal return-tubular boiler of as much heating value as those of the top row?

S. W. M.

In the average boiler setting, the furnace gases are returned from the combustion chamber by easier passages to the top row of tubes than the lowest row of tubes, and therefore the tubes of the top row are usually of greater heating value.

Coal per Horsepower-Hour—What is meant by "coal per horsepower-hour"?

J. C.

The expression "coal per horsepower-hour" means the same as coal required per hour per horsepower continuously developed. A horsepower is the performance of work at the rate of 33,000 ft.-lb. per min., which would be at the rate of $33{,}000 \times 60 = 1{,}980{,}000$ ft.-lb. per hr., and therefore "coal per horsepower-hour" would be coal required per 1,980,000 ft.-lb. of work developed.

Use of Transformers in Same Bank—Will a small transformer operate satisfactorily in a bank with a larger transformer if the load on the bank does not exceed the relative capacity of the smaller transformer?

V. K. S.

The operation will be satisfactory provided the transformers have the same characteristics; that is, the percentage regulation from no load to full load must be the same with both transformers and they must have the same ratio of transformation. If such is not the case the phase relation and the power factor will be disturbed.

Meaning of "12 Pitch"—A gear wheel shown on a blueprint is labeled "12-Pitch." What is meant by the term? I supposed pitch was the distance from center to center of teeth measured along the pitch circle.

C. S. H.

The term "12-pitch" refers to the number of teeth per inch of diameter of the pitch circle. A spur gear having a pitch circle 14 in. diameter would have $12 \times 14 = 168$ teeth. Measured along the circumference of the pitch circle, the distance from center to center of adjacent teeth, or circumferential pitch, would be $\frac{14 \times 3.1416}{12 \times 14}$, or nearly 0.2618 in.

Conversion of Superheated Steam into Dry Saturated Steam—How can superheated steam be changed to dry saturated steam?

W. C. O.

Superheated steam becomes dry saturated steam when it is deprived of heat so as to reduce its temperature to the temperature of dry saturated steam for the particular pressure. The reduction of temperature may be due to loss of heat by radiation as from a steam pipe or steam chest of an engine, or to transfer of heat to water or to wet steam in the presence of the superheated steam, or to the chilling action of the walls of an engine cylinder, or to conversion of the superheat into work by expansion in an engine or turbine.

Piston Sizes in Steam Pumps—Why is it necessary to have the steam piston of a direct-acting boiler-feed pump larger than the water piston?

W. C.

When the pump is used for feeding the boiler from which it receives its supply of steam, the steam piston must be larger than the water piston, because full boiler pressure cannot be realized in the steam cylinder, and also because, in addition to operating the water piston against the boiler pressure, the steam piston must supply the work required for lifting and imparting velocity to the water, for opening the pump valves and check valves, for supplying the work required for overcoming friction of the water in traversing the pipes, valves, fittings and pump passages, and for overcoming the friction of the working parts of the pump.

Compression Pressure in Internal-Combustion Engines—What is the formula for the compression pressure of an internal-combustion engine, knowing the piston displacement and clearance?

B. H. T.

On the assumption that the pressure at the end of the suction stroke is atmospheric, then for conditions of good cooling the formula would be,

$$\left.\begin{matrix}\text{Absolute}\\ \text{compression}\\ \text{pressure}\end{matrix}\right\} = \frac{14.7\ (\text{piston displacement} + \text{clearance})^{1.3}}{\text{clearance}}$$

For less favorable cooling the exponent would be about 1.35, and if there were no cooling, the compression being adiabatic, the exponent would be 1.41.

Steam from a Cubic Inch of Water—How many cubic inches of dry steam can be evaporated from a cubic inch of water?

J. C.

A cubic foot of water at 62 deg. F. weighs 62.36 lb., and therefore a cubic inch of water at that temperature weighs $62.36 \div 1728 = 0.036$ lb. The volume of a pound (weight) of steam depends upon the pressure of the steam. The steam tables show that at atmospheric pressure, or 14.7 lb. per sq.in. absolute, the volume of one pound (weight) of dry-saturated steam is 26.79 cu.ft.; at 65 lb. absolute, or about 50 lb. gage, the volume is 6.65 cu.ft.; and at 115 lb. absolute, or about 100 lb. gage, the volume is 3.88 cu.ft. Therefore, 0.036 lb., or a cubic inch of water at 62 deg. F., when evaporated into steam at atmospheric pressure would occupy a volume of

$26.79 \times 0.036 \times 1728 = 1666.5$ cu.in., at atmospheric pressure;

$6.65 \times 0.036 \times 1728 = 413.6$ cu.in., at 50 lb. gage;

and

$3.88 \times 0.036 \times 1728 = 241.3$ cu.in., at 100 lb. gage.

Cushioning Space in Steam Cylinder of Duplex Pumps—What determines the amount of cushion space in the steam cylinders of duplex steam pumps?

W. H. W.

The purpose of cushioning is to obtain the desired length of stroke of the piston without striking the end of the cylinder, so that the amount of clearance space required to accomplish the necessary cushioning must depend upon operating conditions, such as the steam pressure, back pressure, delivery pressure, friction of pump, speed, weight of reciprocating parts and volume of steam passages. It is on account of the variable amount of cushioning required that cushion-regulating valves are employed to advantage. To meet the latitude of conditions, sufficient cushioning space is obtained, in duplex pumps of ordinary design, by making the contact, or bumping stroke appropriately longer than the nominal stroke. For a nominal 3- to 4-in. stroke the bumping stroke is made about ½ in. longer than the nominal stroke; for 5 to 8 in., ¾ in. longer; for 10 to 15 in., 1 in. longer, etc. On low-service pumps, where the weight of reciprocating parts is great, it is often necessary to provide an extra long cushion to arrest the motion of the piston.

Steam Turbine Blade Fastenings*

By James A. Capstaff†

SYNOPSIS—Describes the methods of fastening turbine blades as used by various builders, and gives detailed results of tests of pulling blades from their fastenings.

Claims on blade fastenings have occupied no mean place in the patent records since Sir Charles A. Parson's first patents were filed in 1884, and it is with the most important of these that I propose to deal.

Repeated tests have proven that the efficiency varies with the blade speed and the number of rows of blades, and that the number of rows varies inversely as the square of the blade speed for a given efficiency. That is to say, if a turbine running at 600 r.p.m. requires 64 rows of blades to show a certain efficiency, another having the same mean blade diameter and the same height of blades would require only 8 rows, if running at 1200 r.p.m., for the same efficiency. From this it will be seen that increasing the number of revolutions per minute offers increased efficiency with smaller turbines, and the tendency is to develop along these lines.

The adoption of reduction gearing opens up a bright future for the further development of the steam turbine. With the direct drive the revolutions of the turbine have to be kept low for propeller considerations; but with gearing the turbine can be designed as an independent unit, without regard to the propeller revolutions. The question is how far can we go on increasing the peripheral speed of the blades and reducing the size of the turbine. For the answer we must look to the strength of the materials used in their manufacture. Theoretically the limit would be reached when the mean blade speed equals between 0.75 and 0.9, that of the steam in the case of a Parsons reaction turbine, and 0.5 in the case of a pure impluse turbine. Quite a common pressure drop through a turbine is from 265 lb. per sq.in. down to 28-in. vacuum. This drop in pressure represents a steam velocity of 4200 ft. per sec.

The possibility of ever reaching the theoretical blade limit is indeed remote, but the tendency is to go on increasing the blade speed. It will be of interest to note here that Messrs. Parsons seldom exceed 550 ft. per sec. at the mean diameter of the last expansion; Curtis as high as 700 ft. per sec., and De Laval 1375 ft. per sec.; all a long way behind the theoretical most efficient speed. With the increase of the revolutions if the diameter is kept down the blade heights must run up. This cannot be done without taxing the strength of the blade and its fastenings.

SHROUDING

In turbines it is highly essential to bind a number of the blades in a row together, either by means of a shrouding or lacing wires, in order to strengthen them against the fatiguing effect of the high period of vibration set up in the blade when running.

It would, of course, be desirable to have this shrouding or lacing, as the case may be, continuous, but owing to expansion troubles due to the use of different metals for the turbine rotor and the blades, this is impracticable. Provision must be made to take care of the expansion. Previous to the adoption of the blade ties, blading gave no end of trouble through breaking at the roots. Shrouding is used on impulse turbines to serve a double purpose. Besides tying the blades it prevents the lateral spreading of the steam jet on its passage across the turbine blade. Shrouding is not absolutely essential on reaction turbines, as the radial clearances between the rotor-blade tips and the cylinder walls are very fine; but some form of binding must be used. Channel shrouding is used by some builders as a safeguard against damage through blade stripping. At the time of its conception, blade stripping was of common occurrence; if one single rotor blade fouled with the cylinder wall the destruction of at least the rows in which it was contained was almost certain.

For some years now Parsons has adopted the clever idea of thin tipping the turbine blades for a small part of their length, and should a revolving blade creep far enough from its root fastening to foul the casting the sharpened tip of the blade will simply be turned over and the rest of the row will not be affected.

In recent years impulse turbines have come to the front. The writer believes that they have much to recommend them, and when the mechanical design receives the attention it deserves, more will be heard of them in naval work. Messrs. Parsons have incorporated an impulse element in their reaction turbines.

WHY ROOT FASTENING IS IMPORTANT

With the development of the impulse turbine in particular the tendency to increase the speed is most marked, and this calls for blades of much heavier section than hitherto used. Heavier blades and higher velocities keep the designer's mind constantly working in the endeavor to provide a root fastening strong and reliable enough to take care of the increasing loads imposed upon it.

Perhaps no field in the design of the steam turbine has been so much exploited as that of blade fastenings, as a survey of the patent records will show. Many ingenious methods have been devised from time to time, the most important of which will be detailed later. Some of the fastenings used today, though highly suitable to meet the conditions existing at the time they were devised, must soon be consigned to the scrap heap or museum, and give place to a fastening of unquestionably superior strength. Too much stress cannot be laid upon the importance of strength. No blade fastening can be too strong. Most builders have, at some time or other, made up a test piece of their particular form of blade fastening and had it pulled to destruction in a testing machine, and demonstrated that it required a pull far exceeding the centrifugal force to which it would be subject when running, to destroy it. But, while a carefully prepared test piece pulled in a testing machine affords excellent material for comparison with other methods, it is poor practice to use the test results as a criterion for running conditions. The unknown quantity enters too largely into this equation. The direct pulling strength of a blade fastening ought to be as great as possible, but not only that, the blade must be rigidly held in every direction with no possible clearance to allow of movement.

Perfect rigidity is the hallmark of excellence in a blade fastening, especially so in an axial direction, for upon this, to a large extent, depends the life and reliability of the fastening. If there should be any initial clearance between the blades and the sides of the grooves, the vibration to which the blades are subject when running under steam may be the means of working the blades loose. Machine fits cannot be relied upon to insure the desired side fit, and calking must be resorted to. Without calking we have no guarantee that the blades completely fill the width of the groove. Calking is the best-known method of assuring biting contact; but while the writer is a keen advocate of its use to insure rigidity, he is not in favor of a blade fastening which relies upon calking for its direct pulling strength. Calking should be employed only as a means of eliminating freedom of movement. Heavy calking is to be avoided on turbine rotors and disks. It distorts them and calls for increased pitches of rows and heavier rotors and disks. In high-speed turbines it is desirable, for reasons of efficiency, to keep down the axial pitch of the rows as much as possible. To do this with a blade fastening of questionable strength and rigidity would be courting disaster.

Before proceeding with a general description of the various methods of blade fastenings, mention should be made of the desirability of giving liberal depth to the groove, as the blade has to rely upon the depth of its fastening for its steadyment.

The blades of the earliest machines built by Messrs. Parsons were made in complete rings which were keyed onto the turbine shaft. The blades were formed by saw cutting the outer circumference of the rings and twisting the edges with pinchers to the desired angles. Experience went to show that while this method might provide the correct angles of entrance and discharge, it left much to be desired in the way of the gradual changes of the course of the steam on its passage across the blade and the smooth polished surface so essential to the efficiency of the turbine. To embody these requirements in a blade was a problem which was solved by making the blades in lengths and sawing to size. Next came the all-important question as to the best means of securing these innumerable blades to their revolving elements. The idea of grooving the rotor, inserting the blades and calking the distance pieces between proved to be a good line along which to work. This method is still used by Messrs. Parsons, al-

*From the May "Journal" of the American Society of Naval Engineers.

†New York Shipbuilding Co.

though the grooves themselves have undergone a number of changes. At first the grooves were plain dovetailed. Then came dovetailed grooves with the sides serrated with grooves of various designs and proportions. After some years the grooves proper were made parallel and V-shaped serrations adopted.

Tests showed that the metal of the distance pieces when calked went more freely into the V serrations than other kinds. The depth of the grooves varies from ¼ in. for blades ¼ in. wide to ⅝ in. for blades 1 in. wide.

The distance pieces are cut $\frac{1}{32}$ in. longer than the depth of the grooves to provide metal for displacing, so that after calking, the distance pieces are flush with the rotor surface. A good idea of the proportions of a Parsons standard reaction blade fastening for rotors may be seen in Fig. 1.

Fig. 2 shows the Parsons' method as applied to impulse blades. Owing to the heavier sections the rotor grooves are made deeper than those for the same width of reaction blades, and in order to insure contact at the lower part of the root the distance pieces are double calked, or, in other words, inserted in two pieces—the lower being calked hard up before the top piece is inserted. The fronts and backs of the blades at the roots are serrated with V-shaped serrations into which metal of the distance piece is driven when calked. It will be noticed in this type of fastening that the holding power of the blade is solely dependent upon its adjacent distance piece; whereas in the Parsons reaction fastening, where the blades are singly inserted, the blades contribute to the holding power, due to the fact that the rotor groove is made narrower than the width of the blades, and the blades are fullered through a degree or two in driving them together in the groove, thereby making a biting contact btween the edges of

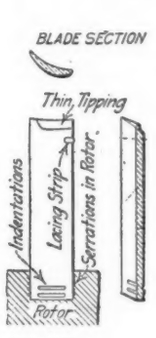


FIG. 1

FIG. 2

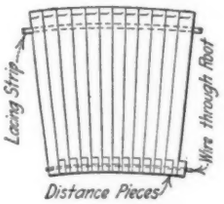


FIG. 3

Fig. 1.—Parsons' reaction blading. Fig. 2.—Parsons' impulse blade fastening. Fig. 3.—Segment of Parsons' rosary blading.

the root of the blades and the side of the rotor groove; the side flats existing at the roots after cutting back the fine edges of the blades do not permit of this being done in the case of impulse blades.

It is the practice with many impulse-turbine builders to allow the distance piece to project up the blade beyond the top of the rotor groove to give the blade increased strength against bending and also provide a truer steam line across the stage. With the Parsons and other methods in which the distance pieces are used as calking pieces, this desirable feature cannot be taken advantage of.

The Parsons method has proved itself to be an excellent fastening for reaction blades running up to 550 ft. per sec. and suitable for impulse turbines of low blade speed, but it has yet to prove itself capable of taking care of the higher speeds suggested as a means of developing maximum efficiency with minimum dimensions. You are referred to the table further on in this paper for test figures on the Parsons blade fastenings.

In order to shorten the time of erection and facilitate repairs, Messrs. Parsons build up their blading in segments such as shown in Fig. 3. The blades and distance pieces have a hole drilled through them near the base and are assembled in a former with a wire threaded through them, which is turned over at the ends to hold the segment together until ready to put into the rotor. This type goes by the name of rosary blading. An earlier attempt at building up this blading in segments is shown in Fig. 4, and was known as the cock's-comb method. It derived its name from the shape of its foundation ring, which was milled out at intervals to receive the blades, giving to it a close resemblance of a cock's comb. After the blades were inserted the points of the comb were knocked over and thus held the blades in position. The life of this type was comparatively short. The fact that it required a groove about 25 per cent. wider than the blade was an objectionable feature.

Segmental blading after being inserted in the rotor groove must be individually calked. This individual calking required by the Parsons method constitutes, to the writer's mind, a weakness, for the reliability of the fastening is dependent upon the scrupulosity of the blader.

Other types of blade fastenings patented by Messrs. Parsons and his associates are shown in Figs. 5 and 6. In Fig. 6

FIG. 4

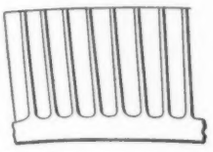


FIG. 5

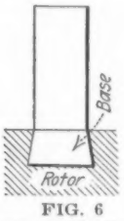


FIG. 6

Fig. 4.—Cockscomb root. Fig. 5.—Early Parsons' blading cut from solid metal. Fig. 6.—Parsons' blade and distance piece combined.

the blades and distance piece are in one and are let into a dovetailed groove, and the distance-piece projection is calked in the usual Parsons way.

An ingenious blade fastening is that of Ferranti. In its simplest form the blades are made of nickel-coated mild steel and electrically welded to the turbine rotor. For marine work the blades are welded to mild-steel foundation rings secured to the rotors, the object being to enable spares to be carried and fitted easily. Such an arrangement is shown in Fig. 7. The rotor or foundation ring is serrated and the bottom of the blade is cut to form narrow projections. The blades are fed singly into the holder of the welding machine, an electric current is passed through the blade, heating the reduced section to a welding heat, and the blade is pressed hard home, uniting it to the rotor or foundation ring. Some time ago the writer had the pleasure of making some pulling tests on this type of fastening and found the weld to be as strong as the blade itself. If reblading had not to be taken into consideration and the blades were welded directly to the rotor, we would have a fastening equal in strength to the blade. As mentioned above, for marine work it is highly desirable to weld the blades on to segments and secure these segments to the rotor. This constitutes the weakest link in the chain. In the list of tests further on in this paper 100 per cent. efficiency was assumed at the weld, and a piece of mild steel of a thickness equal to one blade and a distance piece was secured to the holder by means of a brass side calking piece, and pulled to determine the holding power.

The Westinghouse Machine Co., of Pittsburgh, is the patentee of the fastening shown in Fig. 8. As in the Parsons method, the distance piece forms the anchor. The upset at

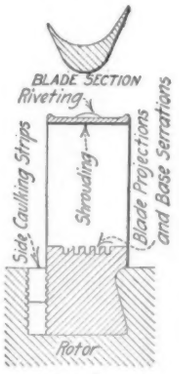


FIG. 7

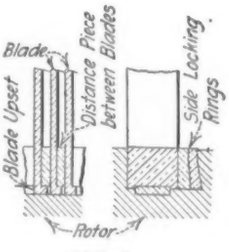


FIG. 8

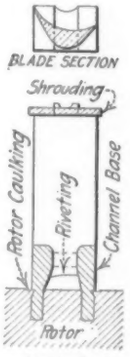


FIG. 9

Fig. 7.—Vickers-Ferranti. Fig. 8.—Westinghouse fastening. Fig. 9.—Fore River fastening.

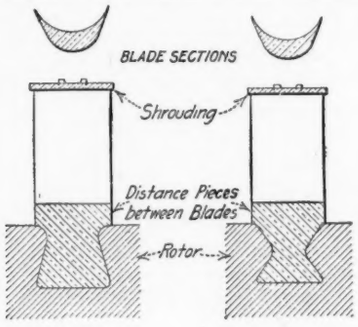
the bottom of the blade provides a reliable connection between the blade and the distance pieces. The side pieces provide side grip for the blades and secure the distance pieces, which are made up of tapered wedges which facilitate assembling and repairs.

Fig. 9 shows the Fore River arrangement. It consists of lengths of steel channel punched at intervals to receive the blades, which are riveted in. The segments of blading are then bent to the curvature of the rotor and inserted in grooves in the rotor. Calking of the sides of the grooves holds the blading in position. It is a particularly clever scheme, but in its present form the part of the channel which receives the

blades is not thick enough, in the writer's opinion, to provide the length of steadyment necessary to keep down the blade deflection within safe limits. With such a short steadyment the demands made upon the riveting are severe. The plain dovetail fastening shown in Fig. 10 is now being used by the Fore River company.

Fig. 11 is favored by the Newport News company. The idea of the double dovetail is to avoid having an abrupt change of blade section at the top of the rotor groove.

The De Laval fastening is an interesting and well-tried-out method. The blades are of nickel-bronze and are drop forged



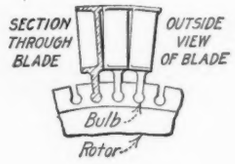


FIG. 10 FIG. 11 FIG. 12

Fig. 10.—Plain dovetail. Fig. 11.—A. E. G. blade.
Fig. 12.—De Laval fastening

with shrouding and roots in one piece. The roots are bulb shaped and are slightly tapered transversely. The rim of the rotor disk is slotted at intervals to receive the blades, which are driven in as shown in Fig. 12.

The blades are not riveted to the shrouding nor are they riveted to the disk. The driving fit used for holding the bulb shanks makes the replacement of blades a simple matter, without danger of distorting the wheel or throwing it out of balance. This result depends upon careful and exact fitting.

The fastening shown in Fig. 13 has not, so far as I know, been adopted on any commercial unit, but its ingenuity is worthy of mention. A dovetailed groove is cut in the rotor

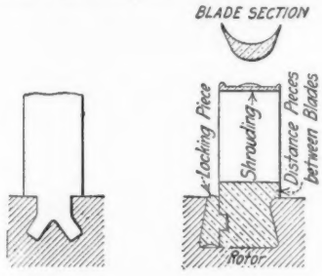


FIG. 13 FIG. 14 FIG. 15 FIG. 16

Fig. 13—Dr. Jude's wedge base. Fig. 14—Lovekin fastening.
Figs. 15 and 16—Closing pieces Lovekin method

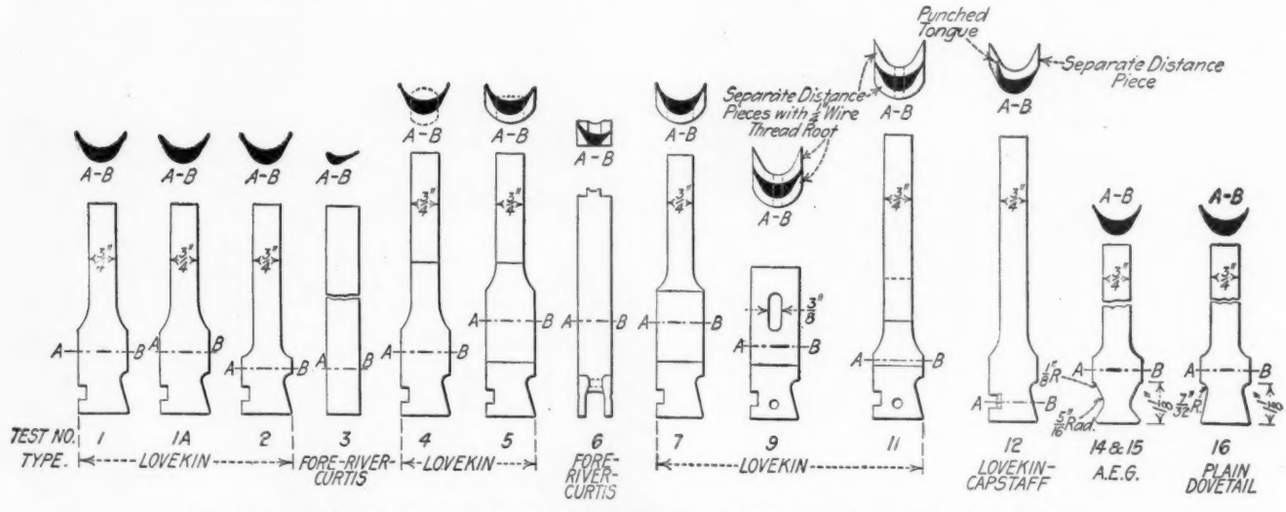


FIG. 17. OUTLINES OF THE VARIOUS BLADES WHOSE FASTENINGS WERE TESTED

with its base forming a wedge and the pressing home of the blades and distance pieces automatically spreads them into the dovetail, filling up the groove. Dr. Jude, of Manchester, England, claims the originality of this method.

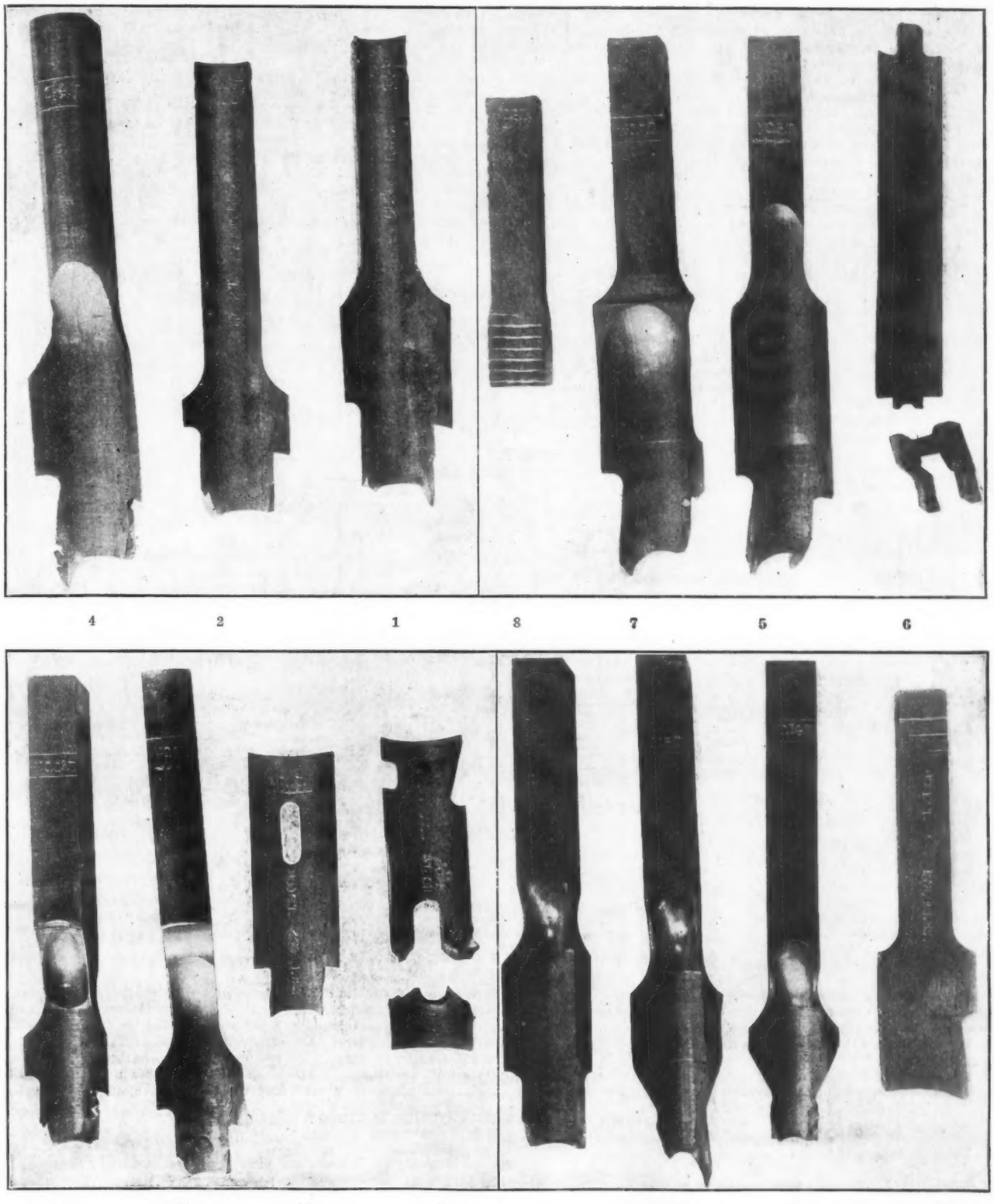
Much credit is due to L. D. Lovekin, of the New York Shipbuilding Co., for the blade fastening he has recently devised, especially in view of the fact that so many designers' minds have been working on this important detail for so many years. Its sound mechanical construction is worthy of the serious consideration of turbine engineers looking for a rigid fastening of great holding power. It is particularly suitable for high-impulse work.

In Mr. Lovekin's method, Fig. 14, the rotor or disk, as the case may be, is grooved with a plain dovetailed groove into which is inserted a tongued locking piece about 12 in. long. Alternately the blades and the distance pieces, whose roots are milled to a dovetail on one side and a recess on the other, are threaded on to this locking piece until the length is made up. Another piece of locking strip is inserted and more blades and distance pieces threaded on and the operation repeated until the entire circumference of the groove is filled with the exception of a piece of locking strip equal in length to two blades and two distance pieces. This length is closed up as shown in Fig. 15 or 16. After assembling one complete row the locking ring is calked well down to make sure that the blading completely fills the groove. Mr. Lovekin's side-locking piece is so designed that, in the process of calking, the roots of the blades and the distance pieces are first brought in contact with the bottom of the groove and then the blades and distance pieces are forced bodily against the side of the rotor groove. It will be noticed that the bottom of the locking piece is undercut, so that, in calking, a sperading action takes place at the bottom and tightens the lower part of the blading as well as the upper. The idea has proved effective. The first three stages of the United States torpedo-boat destroyer "Downes'" turbines were bladed in accordance with the Lovekin method, and the finished result presented rows of blading as perfectly in line as could have been obtained had each blade been trued with a square.

The features of the Lovekin method are: Rigidity; great direct pulling strength; the fact that heavy calking has not to be resorted to to give it its direct pulling strength. Full advantage has been taken of the best-known method of assuring rigidity, namely, side calking; the blading operation is quick, and so simple that the services of experienced bladers are not essential; it is fool-proof.

No special recesses are required around the circumference of the rotor grooves for the insertion of the blades—an item of importance in reblading. Extended distance pieces, so valuable in strengthening the blades against bending and providing a good steam line across the stage can be used. Perfect alignment of the blades in a row is assured. There is no abrupt change of section of blade at the surface of the rotor.

Realizing the many advantages of the Ferranti method, such as eliminating variable circumferential expansion and obtaining an absolute fit of all sectional-base rings by side calking, instead of depending on a machine fit which is impossible in manufacturing, caused Mr. Lovekin to consider the Ferranti method as the most advanced or ideal method yet produced. Therefore, he set to work to design a means of



4 2 1 8 7 5 6

12 11 10 9 16 15 14 13

FIG. 18. TURBINE BLADES AFTER BEING PULLED FROM FASTENINGS

holding turbine blades that would have all of the advantages of the Ferranti method without the disadvantages of welding blades to the base rings, which, as is well known, is difficult and costly and beyond the scope of the engineer at sea to repair in case of breakage. The Lovekin fastening made with monel metal locking ring, calked solidly after all blades have been fitted, enables a result that has not heretofore been obtained. The coefficient of expansion is almost the same as that of steel. Then, again, the simplicity of manufacture is such that anyone can blade or reblade a turbine, whether at sea or in the machine shops. This is of paramount importance.

Realizing that it is unnecessary in the lower circumferential speeds such as used on marine turbines of the direct-drive type (or without the interposition of gearing) to provide the maximum strength of blading, tests were made with the Lovekin blading with various modifications. While the same sectional view as shown in Fig. 14 held good for all the test pieces, the actual construction differed. Test No. 7, Fig. 17, was made with a brass blade and distance piece combined, locked with brass. Test No. 12 was made with a brass blade and separate brass distance pieces; but instead of milling out the blade recess the metal was pressed over to engage in its adjacent distance piece. Two other test pieces were

made up having a brass blade and separate brass distance pieces, with ¼-in. diameter wire through the roots, as shown in Nos. 9 and 11. Tests No. 1-A and No. 2 were made with a brass blade and separate brass distance pieces. There were also test pieces of the Parsons double-calked method, and the Fore River method, No. 6; the fastening as used on the first stage of the Argentine battleship "Moreno's" turbines, No.[1]10; the AEG, Nos. 14 and 15, and the plain dovetail, No. 16. The disadvantage of these three latter methods lies in the great accuracy required in manufacture; while the disadvantage of the Parsons method is its limited application for high centrifugal speeds.

The blade sections used were the latest Fore River Curtis 1.3 in. wide, with the exception of Test No. 6, which was 1 in. wide. It will be noticed that the majority of the test pieces were cut from the bar, the object being to provide a suitable end to accommodate the testing-machine grips.

Fig. 18 shows the test pieces as they appeared after pulling.

In all the Lovekin tests the metal below the recess and the metal at the root of the dovetail was drawn and eventually torn away. The bottoms and sides of the tongues on the locking pieces were locally indented about 0.01 in. in the way of the blades.

In the Parsons' test the metal of the distance pieces, which was calked into the V-serrations of the blades and holder grooves, was sheared off.

In the Vickers-Ferranti test the root of the dovetail was drawn, and shearing of the calked metal took place as in the Parsons test.

The riveted root of the Fore River fastening was drawn parallel.

The other specimens pulled out after drawing and shearing, as shown in the photograph. The test-piece holder was of mild steel, in accordance with Figs. 19 to 22. The projecting piece of the holder was screwed into the weighing head and the blade shank gripped in the jaws of the straining head of a testing machine. The load was applied by the hydraulic straining cylinder, which received its power from a suitable fluid-pressure supply. The essential peculiarity of the "Emery" testing machine is the method by which the stress produced upon the piece being tested is conveyed to the scale

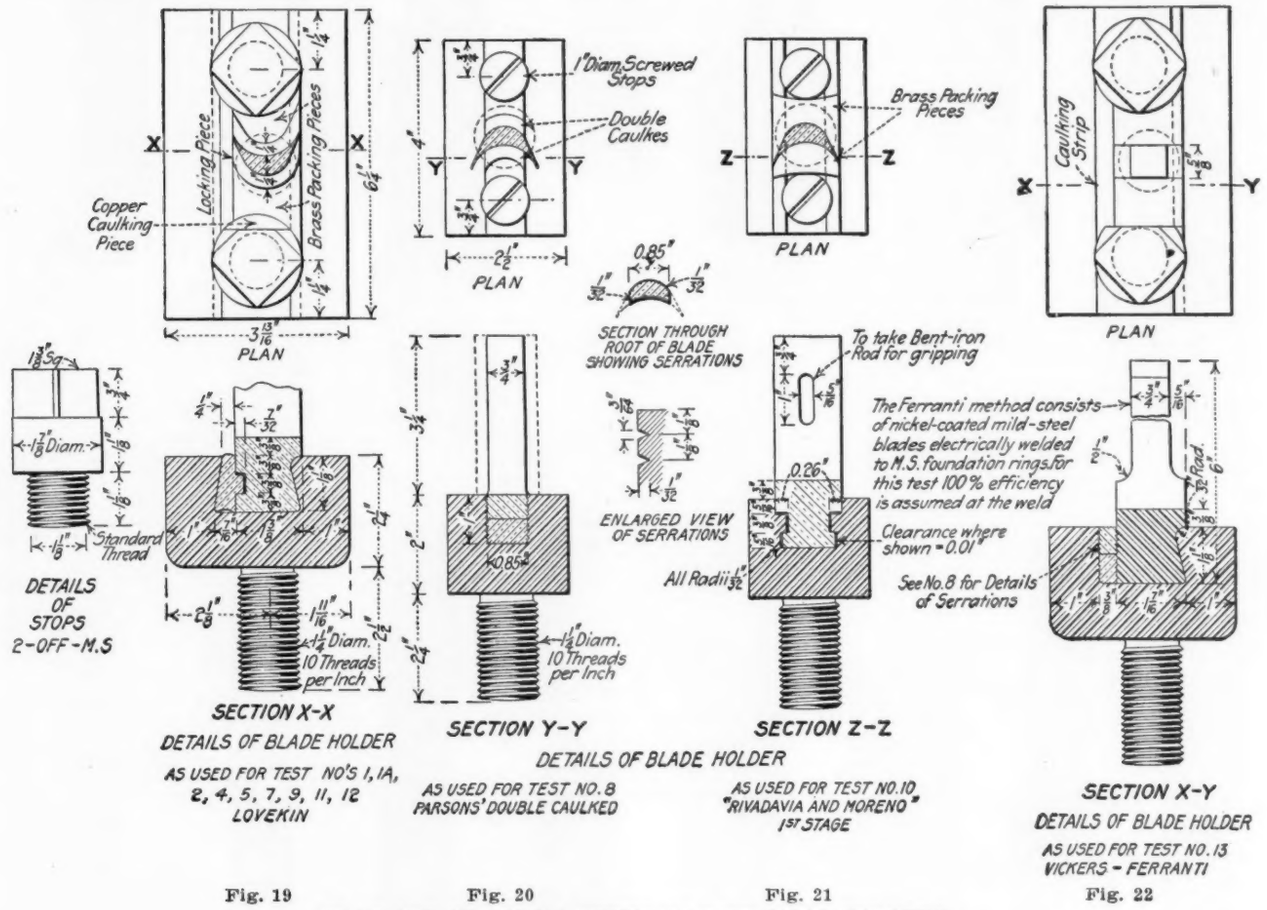

Copper Caulking Piece
Locking Piece
Brass Packing Pieces
PLAN
1" Diam. Screwed Stops
Double Caulkes
PLAN
Brass Packing Pieces
PLAN
Caulking Strip
PLAN
SECTION THROUGH ROOT OF BLADE SHOWING SERRATIONS
ENLARGED VIEW OF SERRATIONS
To take Bent-iron Rod for gripping
The Ferranti method consists of nickel-coated mild-steel blades electrically welded to M.S. foundation rings for this test 100% efficiency is assumed at the weld
Clearance where shown = 0.01"
All Radii 1/32"
See No. 8 for Details of Serrations
Standard Thread
DETAILS OF STOPS 2-OFF-M.S
SECTION X-X
DETAILS OF BLADE HOLDER
AS USED FOR TEST NO'S 1, 1A, 2, 4, 5, 7, 9, 11, 12 LOVEKIN
SECTION Y-Y
AS USED FOR TEST NO. 8 PARSONS' DOUBLE CAULKED
SECTION Z-Z
DETAILS OF BLADE HOLDER
AS USED FOR TEST NO. 10 "RIVADAVIA AND MORENO" 1ST STAGE
SECTION X-Y
DETAILS OF BLADE HOLDER
AS USED FOR TEST NO. 13 VICKERS - FERRANTI

Fig. 19 Fig. 20 Fig. 21 Fig. 22

PLAN AND SECTIONAL VIEWS OF TEST-PIECE HOLDERS

RESULTS OF TESTS ON VARIOUS METHODS

Test No.	Piece No.	Description	Method	Pounds Pull Required — To Start Blade Moving	Pounds Pull Required — To Pull Blade Entirely Out	Locking Piece
13	13	Steel foundation piece with side calking pieces.	Vickers-Ferranti	.....	10,700	Brass
5	5	Monel blade, solid, with distance piece.....	Lovekin	16,900	25,200	Monel
7	7	Brass blade, solid, with distance piece.....	Lovekin	14,000	17,500	Brass
4	4	Monel blade with separate monel distance pieces	Lovekin	9,700	12,300	Monel
11	11	Brass blade with separate D.P.'s with ¼-in. diameter wire through root.....	Lovekin	8,000	10,500	Brass
9	9	Brass blade with separate D.P.'s with ½-in. diameter wire through root.....	Lovekin	Broke at reduced section with 9,800		Brass
12	12	Brass blade with punched tongue, with separate brass distance pieces.....	Lovekin	8,500	10,100	Brass
2	2	Brass blade with separate brass distance pieces.	Lovekin	5,000	7,000	Brass
1A	1A	Brass blade with separate brass distance pieces.	Lovekin	5,000	6,800	Brass
6	6	1-in. brass blade riveted to M. S. channel base..	Fore River	1,500	2,400	.....
8	8	Brass blade with double calked distance pieces..	Parsons	3,400	A continued diminishing load	
10	10	Brass blade with separate distance pieces.....	"Moreno"	3,700	4,700	.....
14	14	Brass blade with separate distance pieces.....	A. E. G.	1,500	9,400	.....
15	15	Brass blade with separate distance pieces.....	A. E. G.	2,500	8,700	.....
16	16	Brass blade with separate distance pieces.....	Plain dovetail	2,400	8,700	.....

All these test pieces were made up at the New York Shipbuilding Co. and pulled to destruction at William Sellers & Co.'s works on its 100,000-lb. Emery testing machine.

and accurately weighed by mechanism that is frictionless, and hence responds equally to the same increment of load regardless of the amount of strain upon the specimen. This result is accomplished by receiving the load upon a flexible diaphragm in a closed cylinder on a hydraulic support. One of these is placed in the scale and a proportionately large one in the machine itself. The pressure received on that in the machine forces liquid to the scale, through a tube, which, acting upon the diaphragm of much smaller area, produces sufficient motion to move the beam of the scale.

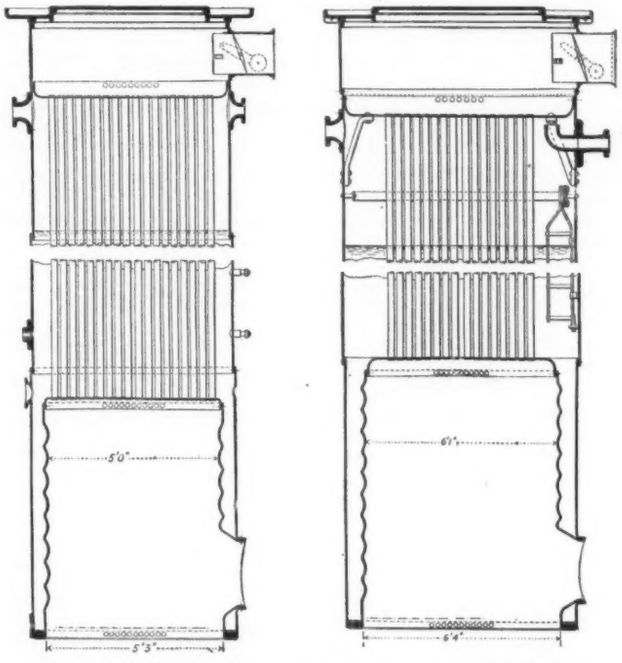
Corrugated Furnaces for Vertical Fire-Tube Boilers*

By F. W. DEAN†

For many years I have been impressed with the value of corrugated furnaces for vertical boilers, but only recently have actually used them.

By the use of such furnaces stay-bolts are done away with and, as there appear to be no disadvantages in the furnace, this is a most important feature. As many hundreds of stay bolts are avoided in each boiler, there are just so many less opportunities for breakage and needed repairs. In the stay-bolted firebox it is necessary for safety to drill holes in the ends of the stay-bolts in order to know when they are broken.

The simplicity of vertical boilers with corrugated fireboxes must commend them to owners and makers. In the boiler



FIGS. 1 AND 2. LARGE CORRUGATED FURNACES IN VERTICAL BOILERS

shop the operations of building are of the simplest and most rapid kind.

This type of firebox provides for expansion and contraction of the tubes in a safe manner, but on account of its somewhat flexible character it should be assumed that it is advisable to support the lower tube plate as near the edge as practicable. The ordinary firebox is rigid vertically and supports the edge of the lower tube plate, but as the corrugated firebox has slight elasticity it is best to hold up as much of the tube plate as practicable by the tubes and provide little or no elasticity in the tube plates. The flat and unstayed portions of the upper and lower tube plates should be made equal in diameter in order to balance.

The flanging of the fire-door presents no difficulty, but it should be done so that the corrugations coalesce with the conical part. The behavior of the firebox end of the boiler when under pressure led to some speculation, for the area of the fire-door opening theoretically unbalances it. When under hydrostatic pressure, various gages were used for showing distortion, but none could be discovered.

In regard to sizes of such furnaces the catalog of the American maker gives 60 in. as the maximum inside diameter, but in fact this company can make them up to 72 in. and almost 1 in. thick. They have been made slightly larger in Germany, and the furnace of the larger boiler illustrated was obtained in that country. If the inside diameter is 72 in., the grate will be 3 in. larger, or 75 in., and the grate area 30.68 sq.ft. It is easy enough to generate 200 hp. on a grate of this size with considerable capacity for forcing beyond this, and there is no difficulty in providing the heating surface for this horsepower.

In regard to pressure, a furnace 72 in. in diameter and 0.95 in. thick will carry 200 lb. If there were sufficient demand for larger furnaces they would probably be forthcoming. The theory of heat transmission through plates, and experience, show that thick furnaces, especially if without riveted joints, are unobjectionable.

The introduction of corrugated furnaces for the fireboxes of the vertical type of boiler is, I think, a real improvement in steam boilers. The type possesses the important qualities of giving maximum and permanent economy, superheating the steam from 20 deg. to 40 deg., being free from brickwork and requiring small floor space per horsepower.

Fig. 1 shows a boiler of the simplest possible design, two of which have been in use for a year and a half, and Fig. 2 shows one with the interior accessible for inspection and cleaning. This has been in use a few months only.

*Presented at the Spring Meeting, June 1915, of the American Society of Mechanical Engineers.

†Consulting Engineer, Boston, Mass.

Some Important Factors in Water-Works Systems

The occasions requiring the design of an entirely new water-distribution system are very rare. The problem usually presented is the design of extensions or reinforcements in an existing system in order to improve pressure conditions. In a paper on "Pipe Distribution Systems," given before the American Water Works Association, Nicholas S. Hill Jr., discussed the external features affecting the design.

The function of a pipe-distribution system is the conveyance of water from the point at which it is delivered to a community to the point where it is to be used. An uninterrupted and adequate supply at satisfactory pressure must be available everywhere on the system under all conditions of demand. The supply must not only meet present and future demands of ordinary domestic and public consumption, but must also care for large industrial consumers and be sufficient for the extinguishment of fires. The problem is to meet not only the average present and future consumer demands, but also such of their maxima as are likely to occur simultaneously.

Proper allowance must be made for the deterioration in the carrying capacity of the mains as a result of tuberculation and other causes. The total annual cost of the delivery of water, which includes fixed charges, replacements, maintenance, and incidental costs chargeable to poor construction, such as losses of water through leakage, must be as low as is consistent with a wise provision for the future growth of the community to be served.

Power Merger in Buffalo

The New York Public Service Commission, Second District, has decided the case of the merger of the Buffalo General Electric Co. with the Cataract Power & Conduit Co. On an opinion written by Commissioner Carr, the commission permits the merger under certain restrictions and under conditions which, according to that opinion, will result in great economic benefits to Buffalo. By the elimination of the Cataract Power & Conduit Co. from the situation, Commissioner Carr points out that the "middleman's profits" will accrue to the users of electricity in the City of Buffalo.

The two companies merged will be operated under the franchise of the Buffalo General Electric Co. in accordance with the provisions of the resolution of the Common Council of the City of Buffalo adopted in January, 1915, providing for a reduction of 19 per cent. in rates to consumers. Moreover, a new contract will be entered into with the Niagara Falls Power Co., which will put the company formed by the merger in as good a position with respect to the purchase of power as the Cataract company.

Recent Court Decisions

Digested by A. L. H. STREET

Engineers as Expert Witnesses—The qualifications required to enable a person to give an opinion bearing upon the safety of power appliances were discussed by the Minnesota Supreme Court in the case of Aultman Co. vs. Mosloski, 79 "Northwestern Reporter," 593, and by the Wisconsin Supreme Court in the cases of Daly vs. City of Milwaukee, and Innes against the same defendant, pages 752 and 783 of the same volume. In the Minnesota case it was decided that the fact that a farmer was licensed to run a steam threshing machine did not qualify him to give an opinion as to whether certain defects rendered an engine worthless; it appearing that he was not a mechanical engineer and did not know whether the defects of the engine could be remedied and, if so, at what cost. In the Daly case the Wisconsin court held that, in a suit to recover for injuries to a fireman, even an expert engineer should not be permitted to state an opinion as to whether a cast-iron elbow, the explosion of which caused the injuries, was obviously safe or unsafe, since that is the ultimate fact to be determined by the jury after considering the facts proved. But it was declared in the Innes case, which arose out of the same explosion as did the Daly case, that a competent engineer could give an opinion as to whether, considering the pressure to which the pipe was subjected, it was reasonably safe and, if unsafe, whether the dangerous condition was so obvious as to be observable to an expert who had charge of the construction of the boiler, had he exercised ordinary care.

Liability for Frightening Horses—Contractors who, through the negligent manner in which they operate a gasoline engine in a street, frighten horses being driven near-by, thereby causing them to run away, are liable for resulting damages sustained by the owner of the horses. Minnesota Supreme Court, Seewald vs. Schmidt, 149 "Northwestern Reporter," 655.)

Duty to Insulate Electric Wires—In a suit against an electric company for death of a mover of houses and mining derricks, caused by his electrocution while he was moving a derrick along a Kansas highway and while attempting to lift over the top of the derrick an uninsulated wire of the company, which was of the size and appearance of a telephone wire, but which, in fact, carried high voltage, the Kansas Supreme Court decided that it was open to the jury to find that the company was negligent in failing to guard against such accidents by maintaining the wire at a higher elevation. The court holds that electric companies that suspend wires charged with high voltage of electricity over or along highways must exercise the greatest care in constructing and maintaining their poles and wires so as to avoid injury to persons using the highways for work, business or pleasure. (Wade vs. Empire District Electric Co., 147 "Pacific Reporter," 63.)

Conveyance of Water Power Privileges—An owner of lots bordering the easterly channel of a double channel on a river conveyed them, together with all water-power privileges appurtenant to them. At the time the conveyance was made the grantor owned other near-by land on which dams and gates controlled the flow of water through the east channel. There was a dam in the west channel. Water gates were in place and were closed only in times of flood. The flow of water diverted by the dam into the east channel was unobstructed, and the flow through a millrace connected with the east channel was limited only by its capacity. The physical situation clearly showed that the only apparent purpose of maintaining the dam was to develop power for the benefit of the lots conveyed. Under these circumstances, it is held by the Supreme Court of Illinois that the conveyance passed to the grantee all of the water power developed by such dam, over which the grantor had control, either as owner of the lots or as owner of the land on which the dam was situated, or otherwise. (Allott vs. American Strawboard Co., 108 "Northeastern Reporter," 284.)

Rights-of-Way for Electric Transmission Lines—The damages to be awarded an owner of land across which right-of-way for maintenance of an overhead electric transmission line is condemned are to be measured by the amount that will compensate for all injury resulting to the land as a natural and direct result of the condemnation. In announcing this rule in the case of Alabama Power Co. vs. Keystone Lime Co., 67 "Southern Reporter," 833, the Alabama Court of Appeals holds that "the law will not permit mere speculative elements of damages, based upon an ill-defined fear that at some unknown and indefinite time in the future some misfortune may come to some man or beast by reason of such improvement, to enter into the consideration of those who, under the law, are required to fix the amount of the damages."

Lease of Power Equipment—According to a late decision of the Arkansas Supreme Court, in the case of Little Rock Ice Co. vs. Consumers' Ice Co., 170 "Southwestern Reporter," 241, where a manufacturing plant is leased by the owner, he is under no obligation to repair or replace worn-out boilers, in the absence of an express promise on his part to do so. The court finds that such obligation was not impliedly created under the lease involved in this case by reason of the fact that it contained a clause to the effect that, if the plant should be destroyed by fire or explosion, the owner might elect whether the plant should be replaced or the lease be canceled.

PERSONALS

Thomas J. McMaster has been appointed district manager for the western territory of the Diamond Power Specialty Co., Detroit, Mich. For the past three years he has devoted part of his time to the Diamond interests, but in the future he will give them his entire attention. His headquarters will be at 809 Ashland Block, Chicago.

Arthur K. Ingraham has completed 45 years of service as salesman for the Joseph Dixon Crucible Co., Jersey City, N. J. Mr. Ingraham is 78 years of age and is said to be the dean of traveling salesmen in this country. His mental keenness and physical alertness give promise of his holding the honor for several years to come. Mr. and Mrs. Ingraham celebrated their golden wedding seven years ago at their home in Mt. Vernon, N. Y.

ENGINEERING AFFAIRS

The National Association of Stationary Engineers will hold its annual convention September 13-18, at Columbus, Ohio.

The Canadian Association of Stationary Engineers will hold its annual convention at Hamilton, Ont., July 20, 21 and 22. It is expected that the number of delegates in attendance this year will be larger than ever before. The mechanical display will be more elaborate than heretofore, the membership in the supplymen's association having been greatly increased. An enjoyable program of entertainment has been arranged by the committee, and a successful convention in every way is looked for.

Power Papers at Engineering Congress—Active preparations are under way at the headquarters of the International Engineering Congress in the Foxcroft Building, Post St., San Francisco, for the congress that is to be held in the new Municipal Auditorium of that city during the week beginning Sept. 20. Prof. William F. Durand, of Leland Stanford, Jr., University, chairman of the Committee on Congresses, is devoting, with a corps of assistants, much time to the editing of the 250-odd papers that have been received, and the planning of entertainments that will fit into the programs of the various engineering societies that will meet in San Francisco during the week preceding the congress. Some of the notable papers in our particular line are: "The Development of the Construction of Turbines in the Netherlands," by D. Dresden; "The 1915 Steam Turbine," by Erik Aug. Forsberg, of the Atiebolaget Separator, Stockholm, Sweden; "The Internal-Combustion Engine of 1915," by Prof. Charles E. Lucke, of Columbia University; "The Diesel Engine in America," by Max Rotter, engineer of the Busch-Sulzer Diesel Engine Co.; "The Boiler of 1915," by A. D. Pratt, of the Babcock & Wilcox Co.; "Hydraulic Power Development and Use," by John Debo Galloway, consulting engineer, San Francisco; "Economics of Electric Power Station Design," by H. F. Parshall, consulting engineer, England; "Lubrication and Lubricants," by Professor Gallup, of the United States; "Waterwheels of the Pressure Type," by Arnold Pfau, consulting engineer of the Allis-Chalmers Co.; "Hydraulic Power Development and Use," by Charles Hamilton Mitchell, B. A. Sc., C. E., consulting engineer, Toronto; "Power-Plant Design," by H. S. Putnam, U. S. A.; "Waterwheels of the Impulse Type," by William M. Doble, of the Pelton Water Wheel Co.; "Turbine Installations," by H. Zoelley, of Zurich, Switzerland; "Application of Diesel Engines to Marine Propulsion," by G. Kloos, of the Netherlands; "Equipment, Processes and Methods for Boiler Shop," by C. E Stromeyer, chief engineer, Manchester (England) Steam Users' Association.